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BULLETIN

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of the

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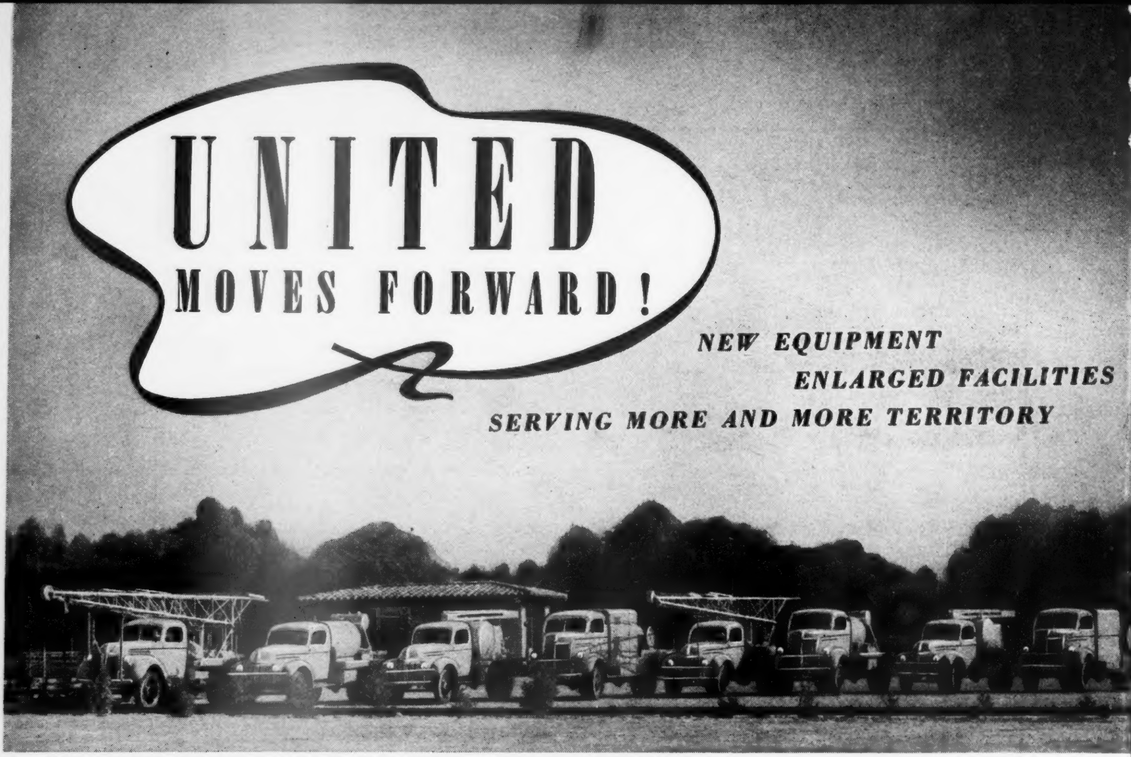

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MAY, 1943

TRAVERSE ROCKS OF THUNDER BAY REGION, MICHIGAN[1]

ALDRED S. WARTHIN, JR.,[2] AND G. ARTHUR COOPER[3]
Poughkeepsie, New York, and Washington, D. C.

ABSTRACT

The Thunder Bay region of Michigan contains the only complete outcrop section of the Devonian Traverse rocks, an assembly described in detail for the first time in this paper.

The lower part of the section contains much shale and alternations of shale and limestone. These comprise, in ascending order, the Bell shale, Rockport Quarry limestone, Ferron Point shale, and Genshaw formation.

Reefs and biostromes are prominent in the middle of the section. The formations resulting from this type of deposition are the Newton Creek limestone, Alpena limestone, and Four Mile Dam formation.

Following the reef stage, shales and impure limestones were deposited to form the Norway Point, Potter Farm, Thunder Bay, and Squaw Bay formations. Older parts of the group are Middle Devonian, but the three last-named formations are Upper Devonian in age.

Unconformities are present in this area at the base and top of the Traverse, at the top of the Alpena limestone, and probably at the top of the Norway Point beds.

INTRODUCTION

The region adjacent to Thunder Bay in Alpena and Presque Isle counties, Michigan, contains fine exposures of the Devonian shales and limestones comprising the Traverse group of rocks. These sediments are of great economic importance in this locality as the source of exceptionally pure limestone, and at other places in the state as a reservoir of petroleum accumulations. In addition they contain some of the finest Devonian fossils known on this continent. Detailed knowledge of the stratigraphy of these rocks will therefore serve both as a guide for further commercial development of mineral resources and a datum for paleontological studies.[4]

Geological studies have been carried on in this region for nearly a century, each worker contributing something to the present knowledge. The writers have

[1] Manuscript received, July 8, 1942. Published by permission of the secretary of the Smithsonian Institution. Part of the expense of illustration is borne by the Beadle Fund of Vassar College.

[2] Department of Geology and Geography, Vassar College.

[3] United States National Museum.

[4] Many groups of fossils have already been described in the "Contributions of the Museum of Paleontology, University of Michigan"; other papers are in preparation.

studied the area since 1926 and 1934, respectively, and here present both new facts and a synthesis of information gathered by previous workers. They are therefore primarily indebted to those men whose names appear in footnotes to this article. They also owe particular gratitude to G. M. Ehlers of the University

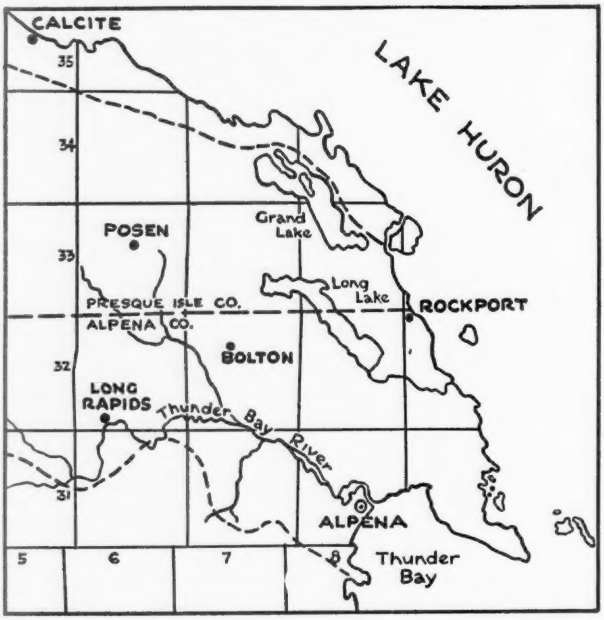

FIG. 1.—Index map of area described. Broken lines indicate limits of Traverse outcrop.

of Michigan, and to many people of the Thunder Bay region for information and assistance in the field.

STRATIGRAPHIC NOMENCLATURE

The first locality name for the rocks now termed the Traverse group was that given by Douglass in 1841.[5] This name was the "Little Traverse Bay limestones," changed to the "Little Traverse Bay group" by Winchell.[6] Rominger visited the Alpena region and published the first extended account of the rock exposures, referring them all to the Hamilton group of New York.[7] Lane[8] in 1893

[5] C. C. Douglass, *Fourth Ann. Rept. State Geol.* (1840), *Michigan Legis. Doc.*, Vol. 1, No. 11 (1841), p. 550. Reprinted in "Geological Reports of Douglass Houghton," *Michigan Hist. Comm.* (1928), p. 579.

[6] A. Winchell, *Michigan Geol. Survey Rept. Prog. 28* (1871).

[7] C. Rominger, *Geol. Survey Michigan*, Vol. 3, Pt. 1 (1876), pp. 38–50.

[8] A. C. Lane, *Michigan Geol. Survey Rept. State Board 1891–1892* (1893), p. 66.

first introduced present usage by referring to the "Traverse group." The curtailment introduces some uncertainty, whether Little Traverse Bay or Grand Traverse Bay, where only the Mississippian Ellsworth shale crops out, is the original locality. In actual practice this ambiguity is unimportant, and there is no need to change the present usage.

Subdivisions of the Traverse group in the Thunder Bay region have been assigned to stage, series, or formation rank by different authors.[9]

Grabau, 1902	*Grabau and Shimer, 1910*	*Ver Wiebe, 1927*	*Pohl, 1930*
Thunder Bay series	Thunder Bay series	Thunder Bay series	Thunder Bay stage
Alpena limestone	Alpena limestone ser.	Alpena limestone	Alpena stage
Lower Traverse ser.	Presque Isle series	Long Lake series	Presque Isle stage
Long Lake ls. and sh.			Long Lake member
Bell shale			Grand Lake member
			Bell shale member

Contemporary practice does not permit the use of the term "series" for a subdivision of a group. Use of the word "stage" implies greater knowledge of the faunal ranges and sedimentary history than now possessed. With this in mind the writers present a subdivision of the group in formations based on a combination of lithological and paleontological criteria. The formations described in the following pages are sufficiently definite entities to permit recognition elsewhere within the Michigan basin.

In this classification the term "Thunder Bay" is used in conformity with the original definition by Douglass. The limits of the Alpena limestone are redefined. The Presque Isle series or stage, with its synonym the Long Lake series, are abandoned. The new name, Rockport Quarry limestone, replaces the term Rockport limestone, which is preoccupied.

Detailed sections are given in the description of each formation. As bioherms and biostromes are of common occurrence, the thickness and character of individual beds may change within a short distance from the site of the measured section.

LIMITS OF TRAVERSE GROUP

The Traverse group is usually understood to include the rocks from the bottom of the Bell shale upward to the base of the Antrim black shale. The beginning of the group is thus marked by a definite lithological change from the underlying Rogers City limestone,[10] and by an erosional unconformity. This unconformity appears to be widespread within the Michigan basin. Although there is a change from limestone to black shale at the top of the Traverse, the actual contact is nowhere exposed and it is by no means certain that there is everywhere an unconformity at that point. The existence of such a break in central Michigan has been

[9] A. W. Grabau, *Geol. Survey Michigan Rept. State Board 1901* (1902), pp. 165–96.
A. W. Grabau and H. W. Shimer, *North American Index Fossils*, Vol. 2 (1910), p. 631.
W. A. Ver Wiebe, "The Stratigraphy of Alpena County, Michigan," *Michigan Acad. Sci., Arts, and Letters Paper 7*, 1926 (1927), pp. 181–92.
E. R. Pohl, "The Middle Devonian Traverse Group of Rocks in Michigan," *Proc. United States Nat. Mus.*, Vol. 76, Art. 14, No. 2811 (1930), p. 25.

[10] G. M. Ehlers and R. E. Radabaugh, "The Rogers City Limestone, a New Middle Devonian Formation in Michigan," *Michigan Acad. Sci., Arts, and Letters Paper 23*, 1937 (1938), pp. 441–45.

recognized,[11] but there is little evidence of its presence other than lithologic change in Alpena and Charlevoix counties. Even this change occurs gradually in many places as indicated by the presence of the "Overlying Transition Zone" of gray shale recognized in well sample studies by Hake and Maebius.[12] In many parts of the state, including the area under discussion, there is a possibility that sedimentation may have been uninterrupted, though changed in character, at the end of Traverse time.

It will be noted that in this paper the Traverse group is interpreted as including rocks of both Hamilton and post-Hamilton ages. There does not seem to be any need at present for a subdivision of the group on this basis.

CORRELATION

In order to clarify the position of these rocks in the geologic column it is necessary to establish a correlation of the Traverse beds exposed in the Thunder Bay region with the rocks originally described under that name, and also with those sediments in New York which are usually regarded as the standard of comparison for the Devonian of North America. These correlations, as determined by the writers, are indicated in the descriptions of formations. Correlation with the type Traverse, between Petoskey and Charlevoix, Michigan, less than 100 miles west of Thunder Bay and in the same structural area, has been accomplished by the discovery of identical species of fossils in nearly identical stratigraphic sequences in the two areas. The chief difficulties in establishing this correlation have been the incomplete exposure, in the area of the type Traverse, and some differences in lithological facies.

The correlation with the Devonian of New York is based on the occurrence of a few identical or closely related species, a number of rare generic types, and a total generic composition like that of certain beds in the New York section. The Devonian exposures in the neighborhood of Thedford, Ontario, are transitional between those of Michigan and New York, and were studied in establishing the correlation. As the New York rocks differ markedly from those in Michigan in lithological facies there are naturally few levels in the column at which direct correlations may be established.

GENERAL GEOLOGY

The topographic relief of the region under discussion is small, few points rising more than 200 feet above the level (standard low water, 578.5 feet) of Lake Huron. Earlier drainage systems were destroyed during the Pleistocene glaciation and swamps and lake basins are now common along the outcrops of the softer shales. The basins, however, do not perfectly parallel the regional

[11] V. R. D. Kirkham, "Unconformity at the Top of the Traverse Formation in Michigan" (abstract), *Bull. Geol. Soc. America*, Vol. 43 (1932), p. 136.

[12] B. F. Hake and J. B. Maebius, "Lithology of the Traverse Group of Central Michigan," *Michigan Acad. Sci., Arts, and Letters Paper 23*, 1937 (1938), pp. 447–61.

strike of the sediments. The northern half of each trends northwest-southeast, approximately along the strike, but the southern half is elongate more nearly north and south, cutting across the limestone lying above the soft shale. The basins of Grand and Long lakes show this shape particularly well. A near duplicate in form of the Grand Lake basin lies beneath the surface of Lake Huron with its north end ½ mile off South Nine Mile Point, in Sec. 27, T. 32 N., R. 9 E. Less well developed, but probably in the same class, is the depression which angles across the floor of Thunder Bay from the southwest corner of T. 31 N., R. 9 E.

The glacial deposits cover the bedrock almost completely except in an irregular belt along the Lake Huron shore. This belt, 2–15 miles in width, was submerged by glacial Lake Algonquin and in part by the later Lake Nipissing; much of the glacial drift was washed away by waves of these lakes. Above the Algonquin beach, therefore, the relief is determined by glacial features, but in the wave-stripped belt the surface forms are the result of bedrock or beach structures.

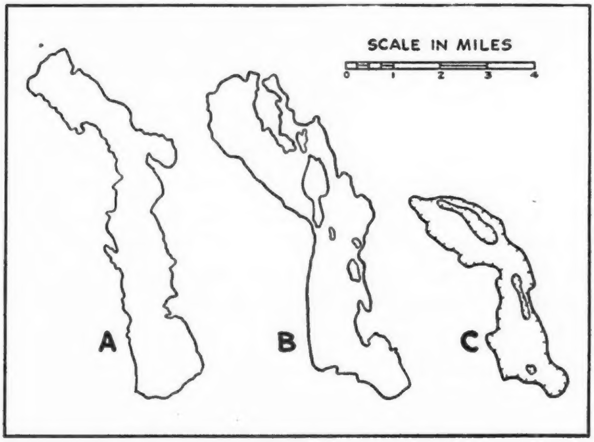

FIG. 2.—Basins in Traverse beds. *A*, Long Lake; *B*, Grand Lake; *C*, basin shown by 45- and 50-foot depth contours southeast of South Nine Mile Point.

This region lies in the northeast part of the Michigan basin[13] and the average strike of the beds is about N. 45° W. The rocks dip about 40 feet per mile southwest. This regional structure is locally modified by minor undulations, larger folds, and biohermal domes. The minor undulations include small domes and anticlines with structural relief of less than 20 feet. Such flexures are well exhibited in the abandoned quarry at Rockport. The larger folds are a mile or more in length but rarely have great structural relief, being merely terraces or noses

[13] For a discussion of the structure and history of this basin consult R. B. Newcombe, "Oil and Gas Fields of Michigan," *Michigan Geol. and Biol. Survey Pub. 38* .Geol. Ser. 32 (1933), pp. 65–124.

on the regional dip. The biohermal domes are not folded structures but areas where the sediments show original or compaction dips flanking the cores of bioherms. These domes are particularly conspicuous in the upper part of the Alpena limestone and are illustrated in Figure 6.

The wave-stripped belt is marked by a number of low cuestas formed by the more resistant beds. The most conspicuous of these is that along the Killians limestone[14] outcrop. This ridge can be traced easily from the NE. $\frac{1}{4}$ of Sec. 36, T. 32 N., R. 8 E., Alpena County, to the southeast corner of Sec. 1, T. 33 N., R. 6 E., Presque Isle County. It ranges in height from 5 to 40 feet, being most conspicuous where it formed shore bluffs on the Algonquin or Nipissing lakes. In the present Lake Huron it forms the edge of the platform on which Gull, Sugar, and Thunder Bay islands rest, in T. 31 N., R. 10 E.

Despite their small thickness the beds of the lower limestones of the Genshaw formation in places produce a recognizable series of cuestas.

Although it lies between the soft Bell and Ferron Point shales the Rockport Quarry limestone does not everywhere produce a conspicuous ridge. In many places it is difficult to locate the outcrop of this limestone, although it once formed a bluff (now quarried away) at Rockport, and makes a 25-foot cliff on the west shore of Grand Lake in Sec. 31, T. 34 N., R. 8 E.

Below the junction with its north branch the Thunder Bay River flows parallel with the strike of the Traverse beds and has migrated downdip sufficiently to produce cuestas in its south bank where the Norway Point and Potter Farm formations crop out.

SINKHOLES

Conspicuous sinkhole areas occur in northern Alpena County and southern Presque Isle County. The surface rocks in most of these belts are either the Alpena or Genshaw formation, but in Secs. 35 and 36, T. 33 N., R. 8 E., Presque Isle County, the Rockport Quarry limestone and the underlying Bell shale have collapsed, indicating solution of rocks older than the Traverse group. Some of the huge pits are approximately 80 feet deep; their bottoms range in elevation from about 100 feet above Lake Huron to 76 feet below the lake level. The latter figure is the depth of the hole in Misery Bay, Sec. 15, T. 31 N., R. 9 E., which may not be a true sink. Instead of receiving water, it discharges considerable volumes after the fashion of the "Blue Hole" at Castalia, Ohio, or the great springs of Florida.

Most of the sinks are well drained and some of them communicate with underground channels capable of receiving large volumes of water. This is true of the sink in the south arm of Devils Lake at the outlet of Long Lake. This pit, which involves at the surface the lower limestones of the Genshaw formation, takes the entire dry season outflow of Long Lake, keeping Devils Lake itself dry and pre-

[14] The stratigraphic position of the formations of the Traverse group is shown in the columnar section (Fig. 3).

venting any surface flow through Long Lake Creek (Hell Creek) into Lake Huron at such times.

It has been suggested[15] that the Sunken Lake sinkhole in Fletcher State Park, 4 miles south of Posen, may be of pre-glacial date, but most of the sinks have collapsed since the retreat of the last ice sheet. This is demonstrated in the sink known as the "Punch Bowl" beside the Long Rapids-Posen highway in the SW. $\frac{1}{4}$, Sec. 15, T. 32 N., R. 6 E. The bedrock at this point is probably the Alpena limestone, but the walls of the pit are composed entirely of glacial drift. The hole is about 250 feet long and 150 feet wide, and is 40 feet in depth. It is inconceivable that the ice should have partly, but not completely, filled with drift a pre-glacial hole of these proportions.

Some of the sinkholes, as Ver Wiebe has pointed out,[16] may owe their origin to the solution of pure and porous *Prismatophyllum* bioherm cores. This would not apply to those sinks where the collapse occurs in rocks older than the upper Genshaw limestone. It is noteworthy that no sinkholes have been found in the bioherm areas quarried in Alpena.

LOCALITIES

In the following stratigraphic discussion repeated references are made to some of the more important outcrop areas. Exact descriptions of these localities, together with a note on the formations exposed at each, are here listed.[17] Localities in the central and western parts of the Traverse outcrop belt are included where it is possible to make correlations with formations of the Thunder Bay region.

Locality

7c Exposures on Lake Michigan shore in low bluff and ledges at unnamed headland 1.3 miles north of pier at Norwood, Charlevoix County; approximately in NE. $\frac{1}{4}$, Sec. 27, T. 33 N., R. 9 W. Section includes beds of possible Squaw Bay and probable Thunder Bay ages.

18a Ledges on shore of Little Traverse Bay at Pennsylvania R. R. station, Bay View, Emmet County. Charlevoix and Gravel Point strata, including "Upper blue shale" of Pohl; correlative in part with Dock Street clay.

23 Exposures along highway, beginning with 22-foot shale bed 200 yards north of Beebe School in center of east line, Sec. 14, T. 34 N., R. 2 W., Cheboygan County, extending thence about $\frac{1}{2}$ mile south. Potter Farm formation.

29 Abandoned quarry of Onaway Limestone Company on shore of Black Lake, Sec. 7, T. 35 N., R. 2 E., Presque Isle County. Rockport Quarry limestone and lower Ferron Point shale; lower Genshaw limestones crop out on hill above quarry.

30 Exposures along Ocqueoc River at and north of highway corner on center, south line, Sec. 22, T. 35 N., R. 3 E., Presque Isle County. Rockport Quarry limestone.

31 Quarry of Michigan Limestone and Chemical Company at Calcite, Presque Isle County. Site of Crawford's "Marble" quarry. Dundee and Rogers City limestones and lower Bell shale.

35 Bluffs on shore of Partridge Point, extending from center into SE. $\frac{1}{4}$, Sec. 11, T. 30 N., R. 8 E., Alpena County. Thunder Bay limestone, type locality.

36 Abandoned limestone quarry in center of S. $\frac{1}{2}$, NE. $\frac{1}{4}$, Sec. 29, T. 31 N., R. 8 E., Alpena County. Potter Farm formation.

[15] O. F. Poindexter, "Sinkholes in the Indian Lake Region, Schoolcraft County, and other Michigan Sinks," *Michigan Acad. Sci., Arts, and Letters Paper 21*, 1935 (1936), p. 442.

[16] W. A. Ver Wiebe, *Michigan Geol. Survey* unpublished report on Alpena County.

[17] This series of numbers, many of them already in print, is used by the University of Michigan, the Michigan Geological Survey, and the United States National Museum.

Locality

37 Shallow abandoned quarry on Alpena-Hillman highway, SE. ¼, SW. ¼, Sec. 19, T. 31 N., R. 8 E., Alpena County. Potter Farm formation.

38 Abandoned quarry of Kelleys Island Lime and Transport Company (Great Lakes Stone and Lime Company) at Rockport, Sec. 6, T. 32 N., R. 9 E., Alpena County. Upper Bell shale, Rockport Quarry limestone, lower Ferron Point shale.

40 Quarry of Michigan Alkali Company, SW. ¼, Sec. 13, T. 31 N., R. 8 E., Alpena County. Upper Genshaw formation, Newton Creek limestone (type locality), Alpena limestone.

41 Exposures on banks and in bed of Thunder Bay River below Four Mile Dam, ¼ mile south of center, Sec. 7, T. 31 N., R. 8 E., Alpena County. Other names currently or formerly applied to this dam site are: Fletcher Dam, Three Mile Dam, Broadwell's Saw Mill. Four Mile Dam formation and Norway Point formation.

46 Shale bank on south side of Thunder Bay River, center of east line, Sec. 18, T. 31 N., R. 8 E., Alpena County. Norway Point formation.

47 Exposures on banks and in bed of Thunder Bay River below Norway Point Dam, NE. ¼, Sec. 12, T. 31 N., R. 7 E., Alpena County. This dam is also known currently as Six Mile or Seven Mile Dam. The waters ponded here cover former dam sites farther up river in Section 2 of same township, where Trowbridge's Mills, Boom Company Dam, and original Seven Mile Dam were located. All beds exposed in vicinity are of Norway Point formation.

51 Abandoned shale pit of Alpena Portland Cement Company, SE. ¼, Sec. 18, T. 32 N., R. 9 E., Alpena County. Upper Ferron Point shales and lower Genshaw formation.

52 Road cut on French Road, center of east line, Sec. 8, T. 32 N., R. 8 E., Alpena County. Genshaw formation, including Killians member.

53 Quarry of Thunder Bay Quarries Company, SE. ¼, Sec. 14, T. 31 N., R. 8 E., Alpena County. Alpena limestone and Four Mile Dam formation.

54 Ledges on beach on south side of Partridge Point, SE. corner, Sec. 10, T. 30 N., R. 8 E., Alpena County. Squaw Bay limestone, type locality.

58 Ditches beside Long Lake Road, NE. ¼, Sec. 22, T. 32 N., R. 8 E., Alpena County. Genshaw formation.

68 Small shale pit at northwest corner of Alpena Cemetery (Evergreen Cemetery), SW. ¼, Sec. 21, T. 31 N., R. 8 E., Alpena County. Potter Farm formation, shales above "Silo Terrace" bed.

STRATIGRAPHY

The formations comprising the Traverse group in the Thunder Bay region are here described, in ascending order. No attempt has been made to give faunal lists for each formation. Most of the species of the Traverse are confined to the Michigan region and are as yet undescribed.

BELL SHALE

1902. Grabau, *Geol. Survey Michigan Rept. State Board* (1901), p. 191.

No specific type locality was mentioned by Grabau but it is reasonably clear that he named the formation from the clay pits (now abandoned) near the former settlement of Bell.[18] These workings are still visible along the county road in the SE. ¼ of Sec. 11, T. 33 N., R. 8 E., Presque Isle County.[19] Only about 3 feet of unfossiliferous blue clay are now accessible.

The Bell shale is poorly exposed because of its ineffective resistance to erosion. The upper beds are best studied in the drainage ditches at the east end of the Rockport quarry (locality 38) where the following section is visible.

[18] The village of Bell was situated on False Presque Isle Harbor in Sec. 13, T. 33 N., R. 8 E., Presque Isle County. The Bell post office was located in the southeast corner of the NE. ¼ of Sec. 34 of the same township.

[19] For this location and other information the writers are indebted to the late H. H. Hindshaw of Alpena.

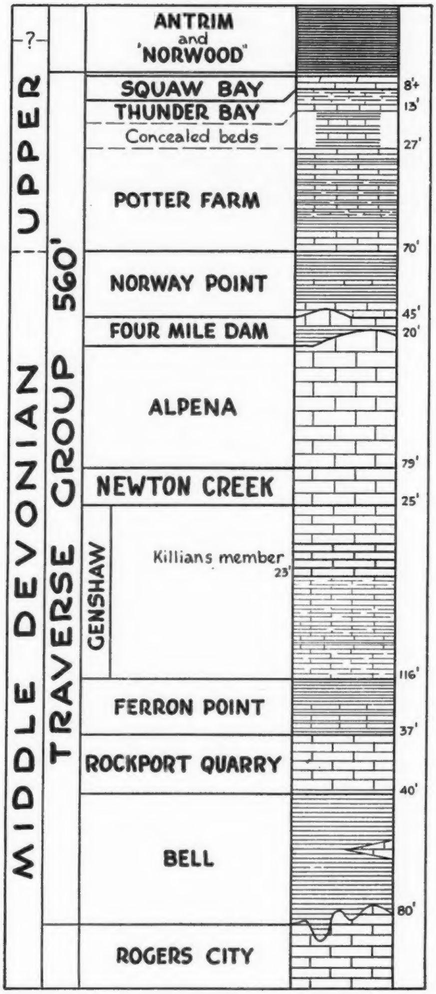

FIG. 3.—Columnar section of Traverse rocks of Thunder Bay region.

	Thickness Feet	Thickness Inches
Rockport Quarry limestone		
3. Limestone, dark bituminous	16	
2. Shale, with limonite stain and alum efflorescence; very fossiliferous		8
Bell shale		
1. Mudstone, bluish gray, darker in color near base; to bottom of ditch	11	

Bed 2, ordinarily included within the Bell, is here referred to the Rockport Quarry limestone as it contains stromatoporoids and other fossils common to that formation. It also contains abundant specimens of *Atrypa* with robust but badly wave-worn shells.

The lowest beds of the Bell shale are commonly exposed in stripping the overburden from the Rogers City limestone quarried by the Kelleys Island Lime and Transport Company at the Lake of the Woods quarry (Sec. 3, T. 33 N., R. 8 E., Presque Isle County) and by the Michigan Limestone and Chemical Company at Calcite (locality 31). At both these places a considerable unconformity is evident, as the top of the limestone is deeply eroded, and the Bell shale rests on an irregular surface, filling joint cracks and caverns.

Although the only outcrops of the Bell are composed of soft calcareous mudstones, it is probable that the formation also contains one or more limestone lenses. In this region the maximum thickness, estimated from local well records, is about 80 feet.[20]

Although no precise correlation with New York is possible, the Bell shale is of Hamilton age, and probably the equivalent of the middle Skaneateles formation.

ROCKPORT QUARRY LIMESTONE

1941. G. A. Cooper and A. S. Warthin, *Jour. Washington Acad. Sci.*, Vol. 31, p. 260.
1916. Rockport limestone, R. A. Smith, *Michigan Geol. and Biol. Survey Pub. 21*, Geol. Ser. 17 (1915), p. 175. Not Rockport limestone of Marbut (1904) and others.

The type locality of this formation is the quarry at Rockport, Alpena County (locality 38). Before the workings were opened here the limestone formed a natural bluff about 16 feet high.

The new name was given to this formation because the term Rockport is three times preoccupied. It might have been possible to use the name Grand Lake limestone originated by Pohl,[21] but as that was never adequately described it seemed best to use a new name as much as possible like that which it replaces.

The section now exposed at Rockport, beginning in the lowest part of the quarry and extending upward on the west wall, is as follows.

	Thickness *Feet*	*Inches*
Ferron Point formation		
7. Clay shale, bluish gray, with limestone lenses	9	
Rockport Quarry limestone		
6. Limestone, gray, sublithographic, with specks of yellow calcite	12	
5. Limestone, gray, bituminous	11	
4. Shale, brown to black, bituminous	1	
3. Limestone, brown, bituminous and pyritiferous	16	
2. Shale, with limonite stains and alum efflorescence; highly fossiliferous		8
Bell shale		
1. Mudstone, bluish gray; to quarry base	11	

[20] The thickness of the Traverse and its formations in this region is consistently less (due to convergence) than that found in wells located nearer the center of the Michigan basin.

[21] E. R. Pohl, *op. cit.*, p. 25.

The most conspicuous fossils of the Rockport Quarry limestone are *Favosites, Prismatophyllum*, and several species of stromatoporoids. These make up the bulk of beds 3 and 5 of the section, occurring as biostromes (extensive flat beds) rather than bioherms (reef knobs).

Bed 6 of the section is much lighter in color than the rest of the formation and is unfossiliferous. Its characteristic blocky weathering is shown in Figure 4. The well worn fossils in bed 2 of the section probably indicate a slight break in deposition at the end of Bell time. After this hiatus the waters cleared sufficiently to allow the growth of corals and stromatoporoids in biostromes.

The Rockport Quarry limestone crops out in a few places on the shore of Lake Huron from locality 38 south to South Nine Mile Point. Northwest from the quarry the formation appears at the surface on the west shore of the north half of Grand Lake. Here, particularly in Sec. 31, T. 34 N., R. 8 E., the lower part is well exposed in a former shore cliff of the Nipissing Great Lakes. The outcrop shows about 25 feet of bituminous coral and stromatoporoid limestone with the fossiliferous shale (bed 2 of the Rockport section) at the base in the waters of the lake.

This formation is also exposed in Presque Isle County at Ocqueoc Falls (locality 30) and in the abandoned quarry at Black Lake (locality 29), where 32 feet of the limestone exhibit the lithologic character of the 12-foot upper bed (bed 6) of the type locality. As the total thickness of the formation is apparently unchanged it is probable that the lithologic character varies with the presence or absence of biostromes.

The top of the formation is commonly marked by a ½-inch layer of pyrite and marcasite which may have been derived from the overlying Ferron Point clays. Except for the abrupt lithological change there is no evidence of unconformity at this horizon.

FERRON POINT FORMATION

1935. Warthin and Cooper, *Jour. Washington Acad. Sci.*, Vol. 25, p. 526.

The name of this formation is taken from Ferron Point on Lake Huron, one mile north of Rockport, but the type section is exposed on the wall of the Rockport quarry (locality 38) ½ mile west of the crusher. The table is numbered in continuation of that for the preceding formation.

	Thickness	
Ferron Point formation	*Feet*	*Inches*
13. Shale, gray, calcareous		6
12. Limestone, gray	2	8
11. Shale, gray, calcareous; many corals	1	1
10. Limestone, a gray massive argillaceous bed, weathering yellow	1	10
9. Claystone, bluish gray	1	10
8. Limestone, blue-gray, argillaceous	1	8
7. Claystone, bluish gray; limestone lenses	9	
Total	18	7
Rockport Quarry limestone		
6. Limestone, gray, sublithographic		

Higher beds also referred to this formation are exposed in the abandoned shale quarry[22] of the Alpena Portland Cement Company (locality 51). The lower part of the section in the quarry is as follows.

	Thickness Feet	Inches
Genshaw formation		
4. Limestone, gray, argillaceous		6
3. Shale, gray, calcareous	5	
Ferron Point formation		
2. Clay, green; abundant *Chonetes* aff. *C. coronatus* (Conrad)	16	
1. Shale, gray, calcareous, fossiliferous; to bottom of drainage ditch	3	

The basal bed of this section contains essentially the same fossil assemblage found in the top bed (13) of the Rockport quarry section. Although the sections unfortunately do not overlap enough to give positive assurance of the identity of these two beds, measurements on two sets of outcrops fail to indicate any covered interval. The whole formation is therefore about 37 feet thick.

Fossils are extremely abundant in this formation and are readily freed from the soft clay. At Rockport bed 7 contains vast numbers of *Prismatophyllum*, *Pentameralla*, *Stropheodonta*, *Cyrtina*, *Atrypa*, and *Athyris*. At locality 51, bed 2 contains a profusion of *Chonetes*.

This formation appears only in artificial openings, ditches or pits because of the softness of the beds. At Rockport the shales were first uncovered in stripping the overburden from the Rockport Quarry limestone in 1928. Before that date the lower part of the formation was known only from a small exposure at the top of the Black Lake quarry, Presque Isle County (locality 29). The upper beds have been exposed at locality 51 for about 40 years, and have been more recently encountered in ditching along the county road on the east side of Sec. 34, T. 33 N., R. 8 E. Strata referable to this formation have also been recognized northeast of Tower, Cheboygan County.

Throughout the eastern half of lower Michigan the shale encountered at this approximate stratigraphic horizon in oil wells[23] is at least in part of Ferron Point age. The Silica shale of northwestern Ohio may represent the southern end of this shale mass.

The upper limit of the Ferron Point formation is marked by the appearance of more calcareous shale containing fossils of the Genshaw formation. Sedimentation was probably uninterrupted.

GENSHAW FORMATION

1935. Warthin and Cooper, *Jour. Washington Acad. Sci.*, Vol. 25, p. 526.

As originally described, the type locality was the NE. ½ of T. 32 N., R. 8 E., Alpena County, the name being taken from the Genshaw School located in the SE. ¼ of Sec. 13. Subsequent field work has revealed that the most characteristic

[22] This company also operated a limestone quarry in the Alpena limestone in the NE. ¼, Sec. 24, T. 31 N., R. 8 E.

[23] B. F. Hake and J. B. Maebius, *op. cit.*, p. 453.

fossils of the Genshaw continue upward for a distance of about 58 feet into limestones above the formation as first defined. It is here proposed to extend the limits of the Genshaw formation to include this overlying 58 feet of rock. The lower 23 feet of this added portion was previously termed the Killians limestone by the writers,[24] and the upper part has usually been referred to the Alpena limestone. The type localities for the amended Genshaw formation are indicated in the following paragraph. Since the Killians limestone is an excellent horizon marker in this region it would be unwise to abandon the name entirely, and it is here considered as a named member within the Genshaw formation.

The following section of the Genshaw formation is a composite, beds 1–7 being measured in the Alpena Portland Cement Company shale quarry (locality 51); beds 6–11 along the Long Lake Road (locality 58); beds 9–14 along French Road (locality 52); intervals 15–17 in the quarry of the Michigan Alkali Company (locality 40).

	Thickness	
	Feet	*Inches*
Newton Creek limestone		
17. Limestone, dark brown, crystalline		
Genshaw formation		
16. Limestone, gray or light brown; small bioherms present in places	25	
15. Limestone in test pit; not exposed	10	
14. *Killians member:* limestone, dark gray to black, with black shale layers	23	
13. Limestone, gray, argillaceous	1	
12. Shale, gray, calcareous	6	
11. Limestone, gray, granular to semicrystalline	9	
10. Shale, gray, calcareous	8	
9. Limestone, gray, granular	3	
8. Shale, gray, calcareous	5	
7. Limestone, gray, argillaceous, massive	3	
6. Shale, gray, calcareous	1	
5. Limestone, gray, argillaceous, massive	3	
4. Shale, gray, calcareous	14	
3. Limestone, gray, argillaceous		6
2. Shale, gray, slightly calcareous	5	
Total	116	6
Ferron Point formation		
1. Clay, green; abundant *Chonetes*		

In Alpena County the individual beds of this formation are fairly constant in lithologic character and thickness. In Presque Isle County there appears to be more variation, for at a location 2 miles northeast of Posen 10 feet of dark limestone appear beneath the Killians member. This may represent a thickening of beds 12 and 13 of the type section.

Natural outcrops of the limestone above the Killians member are rare, but a fair section of bed 16 is visible in the sinkhole in the NW. ¼ of Sec. 11, T. 32 N., R. 7 E., Alpena County.

The massive zone near the top of the Killians member produces the most conspicuous cuesta in this region. In weathered exposures the rock is gray in color and

[24] A. S. Warthin and G. A. Cooper, *op. cit.*, p. 526.

commonly shows an incipient splitting along very irregular bedding planes about one inch apart. The importance of the Killians member in mapping was recognized by Ver Wiebe,[25] who referred it to the lower part of the Alpena limestone.

Though the Killians member is strikingly black and contains black shale beds up to 10 inches in thickness it is worth noting that it is only one of several more or less black strata in the Traverse group. Such beds occur in the lower Rockport Quarry limestone, the lower Alpena limestone, and the Potter Farm formation. Of all these the Killians alone was found to contain large numbers of the charophyte *Trochiliscus herbertae* Peck.

The Genshaw fauna is dominated by brachiopods, many of which reached exceptionally large size.

NEWTON CREEK LIMESTONE

1941. G. A. Cooper and A. S. Warthin, *Jour. Washington Acad. Sci.*, Vol. 31, p. 260.

The quarry of the Michigan Alkali Company at Alpena (locality 40) is designated the type locality. Newton Creek is a small stream flowing across the section in which the quarry is situated. The sequence exposed here is as follows.

	Thickness Feet
Alpena limestone	
3. Limestone, light-colored, with a black shale bed at base	79
Newton Creek limestone	
2. Limestone, dark brown, crystalline	25
Genshaw formation	
1. Limestone, gray or light brown; some small bioherms	25

In this region the middle of the Traverse group is composed of limestone with only a few thin shale layers from the base of the Killians member upward to the top of the Alpena limestone. On gross lithology alone it would be desirable to place this mass under a single formation name, but since it contains three distinct units with different faunas and geographic distribution such a correlation would lead only to confusion. It seems wisest to include the lower part of this mass in the Genshaw formation, and to designate the brown central beds the Newton Creek limestone and the upper biohermal beds the Alpena limestone.

The brown color of the Newton Creek limestone is due principally to its interstitial petroleum content, a feature that it shows not only at its type locality, but as far west as Afton, Cheboygan County.

The extraordinary cephalopods described by Foerste[26] all came from this formation. Many cephalopods and brachiopods collected at locality 40 exhibit color patterns on the shell.

The Newton Creek limestone forms a conspicuous layer at the type locality, being the darkest limestone there exposed. Natural outcrops of the formation are

[25] W. A. Ver Wiebe, *op. cit.* (1927), p. 186.

[26] A. F. Foerste, "Devonian Cephalopods from Alpena in Michigan," *Univ. Michigan Contrib. Mus. Geol. 2* (1927), pp. 189–208.

difficult to find as it tends to crumble with exposure to weathering. Numerous drift blocks indicate the presence of this bed along the road at the center of the east line of Sec. 17, T. 32 N., R. 8 E., and in the SW. ¼ of Sec. 11, T. 32 N., R. 7 E.

ALPENA LIMESTONE

1902. Grabau, *Geol. Survey Michigan Rept. State Board* (1901), p. 175.

This name was originally applied to the rock exposed in the neighboring quarries of Owen Fox and Richard Collins (SE. ¼, Sec. 14, and SW. ¼, Sec. 13, T. 31 N., R. 8 E., respectively). The first of these has been superseded by the workings of the Thunder Bay Quarries Company (locality 53) and the second by the deep quarry of the Michigan Alkali Company (locality 40). A much more extensive sequence of beds is exposed now than at the time of Grabau's studies. The original definition applied the name only to the 35 feet of limestone exposed in the early quarries, but the use of the term "Alpena limestone" has changed as quarrying operations increased in depth. After the pit at locality 40 reached its present depth of about 125 feet it was proposed by Ver Wiebe[27] to apply the name to the entire section there exhibited. For the reasons mentioned in discussing the Newton Creek limestone this course is considered inadvisable, and the term seems best restricted to the beds originally described by Grabau plus about 40 feet of the subjacent limestone. The section of these beds now exposed at locality 40 is as follows.

	Thickness Feet
Four Mile Dam formation	
6. Mudstone, bluish gray, calcareous, in occasional patches (Dock St. clay)	0–7
Alpena limestone	
5. Limestone, white, light gray, or light brown in color, with many bioherms	57
4. Shale, bluish gray; highly calcareous and fossiliferous	1
3. Limestone, white or light gray, massive	20
2. Shale, black, bituminous	1
Total Alpena 79 feet	
Newton Creek limestone	
1. Limestone, dark brown, crystalline	25

The calcareous shale (bed 4) is persistent over the entire quarry but the black shale (bed 2) appears only locally. The bioherms of bed 5 have in many instances been stripped of overburden in the quarrying operations and now project above the general surface with their original relief. Bioherms are not present in bed 3 at locality 40, but apparently occur in this bed along the highway on the east side of Sec. 3, T. 32 N., R. 8 E., 2 miles northwest of the quarry.

BIOHERMS AND BIOSTROMES

During most of Traverse time corals and other limestone secreting organisms were able to live successfully in this region. Even in the Bell shale, where rapid deposition of mud must have been a serious threat to sedentary sea bottom life,

[27] W. A. Ver Wiebe *op. cit.*, p. 185.

remains of *Prismatophyllum* and of simple corals are fairly common. At that time these corals were not, however, able to live long individually, and they did not become abundant.

At other times the sea in this region was probably clear, shallow, warm, and without too vigorous wave action on the bottom. These favorable living conditions allowed the coral and stromatoporoid colonies to grow to large size, and in sufficient numbers to form a continuous layer of limestone. Such a layer is in no sense a "reef"; it never stood above adjacent parts of the sea floor, and although produced by the same organisms that build reefs it is simply a limestone sheet of comparatively constant thickness and lithologic character. This type of deposit is called a *biostrome* to distinguish it from the reef knobs or *bioherms*. The lower parts of the Rockport Quarry and Alpena limestones are excellent illustrations of these biostromes.

During the time of deposition of the upper part of the Alpena limestone conditions still favored the growth of corals and stromatoporoids, but this growth did not proceed evenly over the entire bottom. In areas of limited extent the organisms grew in abundance and to large size, but otherwise the colonies were few and small. The cause of this condition is not definitely known. A slight deepening of the water may have killed off all but a few scattered colonies which were able to survive and grow upward into their customary depth. A slight shoaling of the water might produce the same effect, the increased wave action destroying many of the colonies and burying others beneath débris. Whatever the cause, it fostered growth of the colonies in scattered groups, producing small knobs on the sea floor. Each knob, together with its immediately flanking sediments, is a bioherm, and the aggregation of knobs is probably best called a reef. It has not been demonstrated, however, that the platform on which the knobs grew was actually raised above the general sea bottom, as is usual in present-day reefs.

Within the core of the bioherm there is no definite bedding of the limestone, this being obscured by the jumble of coral and stromatoporoid colonies and their débris. As this material is in the nature of a breccia it naturally follows that the unbedded core is more porous than the flanking sediments. This porosity is increased by the abundant natural openings within the fossils themselves.

The high porosity of the bioherm core has not concentrated sufficient ground water flow to form open channels or caves in as many instances as might be expected. This may be observed in the comparatively dry condition of the quarries at localities 40 and 53. It is probable that the high porosity of the bioherm core is counterbalanced by the lower porosity and permeability of the limestone beneath and around the core, restricting water circulation. That such circulation does sometimes occur is indicated by the occasional presence of chert and dolomite in the cores, these minerals being of secondary introduction.

The bioherms studied show little evidence of having contained much petroleum in the pore space. The underlying Newton Creek limestone generally shows more oil color, odor, and residues than do the bioherm beds.

FIG. 4.—Upper Rockport Quarry limestone, showing blocky weathering, overlain by shales and thin limestones of lower Ferron Point formation. Rockport Quarry, locality 38.

FIG. 5.—Quarry of Michigan Alkali Company at Alpena. Alpena limestone bioherms are quarried on upper level. Dark Newton Creek limestone is visible near power shovel.

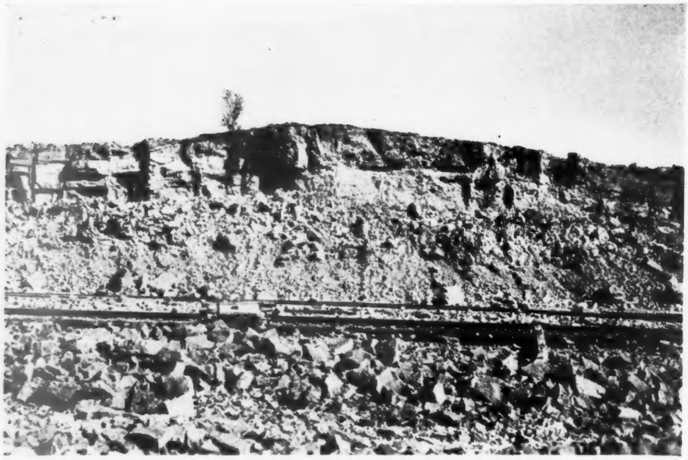

FIG. 6.—Cross section of an Alpena limestone bioherm, showing structureless core and dip of flanking sediments. Michigan Alkali Company Quarry, Alpena.

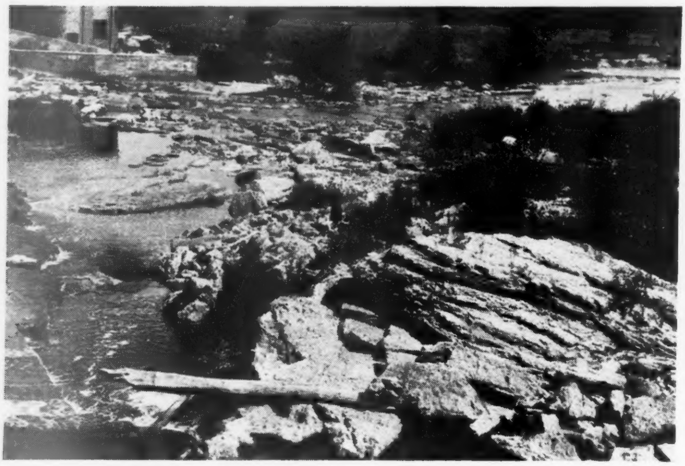

FIG. 7.—Four Mile Dam limestone and overlying Norway Point shales at Four Mile Dam, Alpena County. Log marks contact.

The bioherms of the Richard Collins quarry were described by Grabau,[28] but the present magnificent exposures of these uncommon structures deserve a further comment. The unbedded cores of the bioherms are round or oval in plan and have a maximum diameter of about 150 feet. The greatest observed thickness of any bioherm core is about 55 feet; its actual relief above the sea floor was rarely more than 15–20 feet. An isolated bioherm probably would produce an appreciable original dip in the flanking lime-sands at a distance of 600 feet from the center, but the reef knobs are too closely crowded to demonstrate this fact. The steepest dips in the flanking beds are found close to the cores of the smaller bioherms.

The beds flanking the central mass of each bioherm are composed of a lime-sand, the particles of which are comminuted fossils. This material, as well as the central core, is often extremely porous. The relatively free migration of water through the pores may have been responsible for the introduction of the chert and dolomite found in association with some of the bioherms.

Prismatophyllum, stromatoporoids, and *Favosites*, in that order, seem to have been the organisms most important in building the bioherms. In the Alpena limestone, colonies of these fossils reach remarkable size both in the bioherms and the platform on which they rest. At locality 40 colonies of stromatoporoids 15 feet in diameter are not uncommon.

The Alpena limestone contains the lowest bed of the Thunder Bay region which may be correlated by fossils with the type Traverse rocks of western Michigan. Bed 4 of the Michigan Alkali Company quarry section contains *Chonetes emmetensis* Winchell and other fossils similar to those found in the "Emmetensis zone" of the lower Gravel Point stage in Charlevoix and Emmet counties.

FOUR MILE DAM FORMATION

1941. G. A. Cooper and A. S. Warthin, *Jour. Washington Acad. Sci.*, Vol. 31, p. 260.

This formation comprises the thin beds lying between the Alpena limestone and the Norway Point formation. The type section is located at the foot of the Four Mile Dam on the Thunder Bay River (locality 41), where the following beds are visible.

	Thickness Feet
Norway Point formation	
About 25 feet of this formation are exposed, the lowest bed being	
2. Shale, gray, calcareous, irregularly bedded	12
Four Mile Dam formation	
1. Biohermal limestone, light gray, brecciated, interspaces filled with bluish green clay; to the river bed	8

Three of these small bioherms occur in the river bed and the local doming which they have produced is responsible for the location of the dam at that point. The bioherm breccia contains an exceptional group of fossils known elsewhere in the Centerfield of New York and the Beechwood limestone of southern Indiana.

[28] A. W. Grabau, *op. cit.*, pp. 176–78.

The stratigraphy of these post-Alpena sediments is extremely complicated. The type of sediment and the thickness of the section both vary within short distances. Although the total thickness probably is not more than 20 feet it is impossible to give a single typical section or even to assemble a composite section for these beds with any assurance of its accuracy or completeness.

At the end of Alpena time the sea floor in this region was studded with bioherm knobs which may have produced local differences in elevation of 30–40 feet. The growth of the great Alpena bioherms at localities 40 and 53 ended with the appearance of muddy waters which deposited clay around and over the knobs. At other places the bioherms may have survived the new conditions for a time. The changes at the end of Alpena time seem to have involved slight erosion, muddying of the water, and the introduction of new forms of life.

A clay facies of these beds has already been termed[29] the Dock Street clay from a test well record in the city of Alpena. Though the name was perhaps not proposed as a formation term it has been used more than once and will probably continue in use because of the remarkably well developed, beautiful fossils which the bed contains. This clay, actually a soft mudstone which weathers within a few weeks after exposure into bluish gray clay, is fossiliferous in restricted areas, where echinoderms are found in a remarkable state of perfection. Among these are the crinoids *Magistocrinus* and *Dolatocrinus*, and the blastoid *Nucleocrinus*.

The best available section showing the Dock Street clay, here considered a named member of the Four Mile Dam formation, is at locality 53, where in the southeast part of the quarry pit the following beds were measured.

	Thickness	
	Feet	*Inches*
Glacial lake deposits		
Four Mile Dam formation		
4. Limestone, brownish gray, with sandy shale partings	5–6	
3. Limestone, gray, crystalline	2	6
2. Mudstone, calcareous, bluish gray	7	6
Alpena limestone		
1. Limestone, gray, in bioherms		

Bed 2 of this section is the Dock Street clay, containing the echinoderms previously mentioned and also brachiopods from the Centerfield formation of the Hamilton group in New York. Bed 3 contains another Centerfield fossil, *Spirifer venustus* Hall.

The relation of these beds to those of the type locality can not be determined with great exactitude. The clay in the cavities of the breccia at locality 41 might suggest the Alpena limestone-Dock Street clay sequence, but careful search of the bioherms at localities 40 and 53 has not revealed the fossils discovered in the bioherm at the Four Mile Dam. The occurrence of *Spirifer venustus* above the Dock Street clay at locality 53 indicates strongly that the Four Mile Dam bioherm, which contains the same fossil, is younger than the Dock Street clay.

[29] A. W. Grabau, *op. cit.*, p. 192.

It is not clear whether the Four Mile Dam bioherm should be classified as a late phase of the Alpena limestone or as a separate unit. In order to facilitate reference to these important fossil localities it is proposed that the name Four Mile Dam be used for all these thin beds, and that any further attempt at classification be postponed in the hope that future quarrying operations may reveal new evidence.

The discovery of the fauna with Centerfield affinities at the Four Mile Dam provides a significant horizon for correlation. Many of the fossils found here have, as a group, a very restricted vertical range combined with wide geographic distribution. To the east this same group occurs in the "Coral zone" of the Widder beds in Ontario, and in the Centerfield limestone of the Hamilton group of New York. Although these fossils have not yet been discovered in the type region of the Traverse their approximate position in western Michigan is indicated by the occurrence of the Dock Street clay fossils near the base of the section on the shore at Bay View, Emmet County (locality 18a).

The appearance of this group of marine animals in Michigan and New York must have been accomplished in a continuous sea with uniform bottom conditions over the entire area. Even under the most favorable environment the migration of brachiopods over such a distance takes enough time so that absolute contemporaneity of the Michigan and New York occurrences is unlikely unless both received the fauna simultaneously from some third region. That the New York beds may be slightly older is indicated by the fact that the Ostracoda (presumably more rapid migrants than Brachiopoda) of the Centerfield first appear in numbers in Michigan in the calcareous shale in the middle of the Alpena limestone.

If the postulated bottom conditions allowed free migration from New York to Michigan during Centerfield time it is reasonable to expect some opposite movement of Traverse species into New York in the same sea. Evidence of such a movement is seen in the fact that more Traverse types occur in the Centerfield than in any other bed in the Hamilton of New York.

NORWAY POINT FORMATION

1935. Warthin and Cooper, *Jour. Washington Acad. Sci.*, Vol. 25, p. 525.

The rocks exposed below the Norway Point Dam on Thunder Bay River (locality 47) furnish the best type section. Neither the top nor bottom of the formation is visible at this place, but the most characteristic beds are well exposed. The section is as follows.

	Thickness Feet	*Inches*
Glacial drift		
Norway Point formation		
10. Clay, bluish gray, with siltstone lenses	11	
9. Shale, bluish gray, calcareous and highly fossiliferous	3	
8. Limestone, gray, coarsely crystalline	1	3
7. Shale, gray, calcareous and arenaceous, irregularly bedded	12	
6. Limestone, gray, finely crystalline; a single massive bed		6

	Thickness Feet	Inches
5. Limestone, gray, coarsely crystalline, fossiliferous	1	
4. Limestone, gray, finely crystalline, fossiliferous	3	
3. Limestone, brown, finely crystalline; surface sandy on weathering	1	
2. Limestone, brown, fossiliferous	1	
1. Limestone, brown, stylolitic; to the river level		6

Another exposure (locality 46) contains 19 feet of the upper clay (bed 10). Bed 1 is exposed on the sharp dome on the north bank of the river; it is not the true base of the formation. The maximum known thickness of the Norway Point is 45 feet; it may reach 55–60 feet in some parts of the region.

This formation was deposited on an irregular surface studded with the small bioherms previously described. As a result some of the lower beds are overlapped on the higher hummocks. Such a condition is found at the Four Mile Dam (locality 41) where beds 1–6 of the type section have been lost by overlap, and bed 7 rests directly on the bioherm.

Beds which are the equivalent of, and perhaps in part older than, intervals 1–6 of the type section crop out in the bed of the north branch of the Thunder Bay River just south of the center of Sec. 29, T. 32 N., R. 7 E., and also along the highway from the County Farm to the northwest corner of Sec. 9, T. 31 N., R. 8 E. At the latter locality a probable thickness of 18 feet is indicated for these lower beds.

Beds of Norway Point age have been recognized as far west in Michigan as locality 26, near Afton, Cheboygan County, but have not yet been identified in the type region of the Traverse group.

The Norway Point appears to be equivalent to some part of the Ludlowville formation, probably the lower Wanakah shale but possibly as high as the Tichenor limestone, in New York. It is the youngest formation in Michigan with definite Hamilton affinities.

POTTER FARM FORMATION

1935. Warthin and Cooper, *Jour. Washington Acad. Sci.*, Vol. 25, p. 525.

The F. N. Potter farm, in the east halves of Secs. 18 and 19, and Sec. 20, T. 31 N., R. 8 E., Alpena County, contains the most complete exposed sequence of these beds. The following section of this formation is a composite of two series of measurements, the lower part being taken just south of the Four Mile Dam (locality 41) and the upper part on a northeast-southwest line across the SE. ¼ of Sec. 20 from locality 68. The key bed by which the two sections are united is bed 4, a layer sufficiently conspicuous in outcrop to be given a separate informal name "Silo Terrace" by Ver Wiebe.[30]

	Thickness Feet	Inches
Glacial drift		
Potter Farm formation		
18. Limestone, dark gray, argillaceous; many corals and stromatoporoids	3	
17. Covered interval?	5?	

[30] W. A. Ver Wiebe, *op. cit.*, p. 189.

	Thickness Feet	Inches
16. Limestone, gray, crystalline; corals	1	6
15. Covered interval	1	
14. Limestone, gray, sublithographic	2	
13. Covered interval	2	
12. Limestone, gray; ordinarily conspicuous in outcrop; irregular bedding shows on weathered surfaces	10	
11. Covered interval	3	
10. Limestone, massive, becoming rusty and very porous on weathering	5	
9. Shale, gray, calcareous; few fossils	3	6
8. Limestone, gray, massive, finely granular	2	
7. Shale, gray, calcareous; fossils common, including corals and a large *Cranaena*	2	6
6. Limestone, gray, argillaceous	2	6
5. Limestone and green clay in alternate beds; nearly all clay in lower part, the limestone increasing upward, the top 5 feet being almost entirely calcareous; fossils abundant	19	
4. Limestone, brown, crinoidal, massive	8	
3. Limestone, crinoidal, in thin layers with shale partings	5	
Norway Point formation		
2. Covered interval, of which at least 13 feet and probably the entire interval is occupied by the blue clay of this formation	18	
1. Clay, blue, with siltstone lenses	6	

Bed 18 is known only from the shallow quarry at locality 37. The covered interval 17 may not actually exist as beds 18 and 16 are perhaps separate outcrops in different facies of the same bed. The known thickness of this formation is therefore between 68 and 74 feet.

Bed 12, which forms the top of the hill where the state highway crosses the Potter Farm, is also exposed on the township road about 500 feet south of the center of the north line of Section 19. At locality 36 the limestone containing large nodose gastropods may be a representative of this horizon or of bed 10. Bed 12 perhaps underlies Bare Point on Thunder Bay. Although no outcrop is known there the point is thickly strewn with boulders of this type of rock.

Bed 5, the most fossiliferous horizon of this formation, is best exposed just off the Potter Farm on the cemetery property (locality 68). It was formerly exposed in the now obliterated pits of the Warner Brickyard at the bend in Third Street in the southwest part of Alpena.

Bed 4, the "Silo Terrace," makes a recognizable cuesta from the center of the south line of the NE. $\frac{1}{4}$ of Sec. 20 to the road corner 200 yards south of the Four Mile Dam. It is best exposed 250 yards west of the Thunder Bay River bridge of the abandoned Boyne City, Gaylord, and Alpena Railway. Stony Point on Thunder Bay is probably formed by this bed, and its continuation into the waters of the bay can be seen in the 5-foot shoal $1\frac{1}{2}$ miles east of Bare Point.

The area known as Orchard Hill, in the N. $\frac{1}{2}$ of Sec. 31 and the S. $\frac{1}{2}$ of Sec. 30, T. 32 N., R. 7 E., is a dome rising about 50 feet above the Thunder Bay River valley. The surface rocks on this structure belong to the Potter Farm formation, and the dome may be a large covered bioherm of the Alpena or Four Mile Dam limestones.

Between this formation and the overlying Thunder Bay limestone a considerable covered interval complicates interpretation of the sequence. The thickness

and lithology of the rocks contained in this interval may be inferred from a study of U. S. Lake Survey chart No. 535, showing the bottom configuration of Thunder Bay. Beach deposits of the present lake stage cover only a shallow zone near the shore, and in 15–30 feet of water the bedrock ridges are easily discerned on the chart. With an assumed southwesterly dip of 39 feet to the mile, the northern

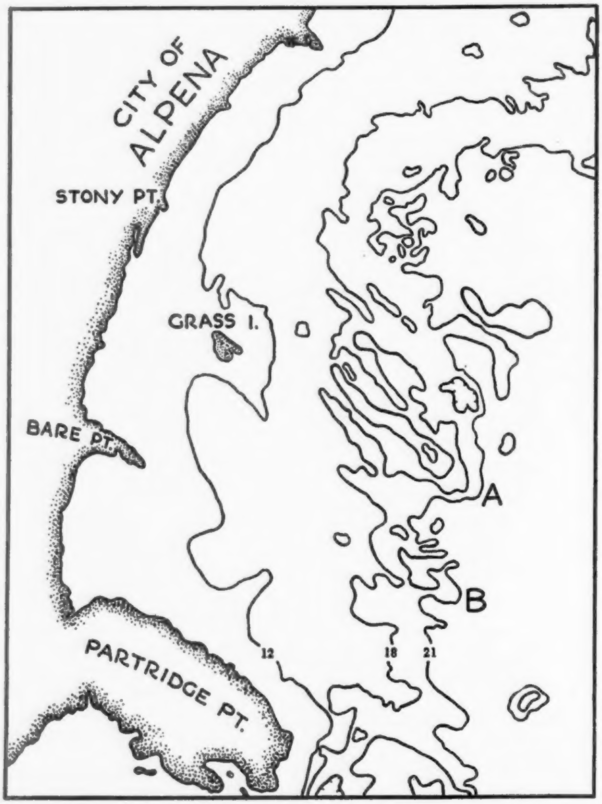

FIG. 8.—Bottom contours of part of Thunder Bay, after *U. S. Lake Survey Chart 535*. Ridge *A* is probably the "Silo Terrace" bed and ridge *B* is bed 12 of the Potter Farm section. Width of map, 3 miles.

ridges fit admirably, in spacing and relative strength, the known beds of the Norway Point and Potter Farm formations. The covered interval between the highest Potter Farm beds and the Thunder Bay limestone, as inferred from the chart, contains about 27 feet of rocks including two particularly resistant members which are probably limestones.

The correlation of the Potter Farm beds with the New York Devonian is difficult. The fauna is quite unlike that of the Norway Point beds below. If the Norway Point is upper Ludlowville in age the Potter Farm beds must be not only post-Ludlowville but perhaps post-Hamilton in age, as they have little in common with the Moscow formation. The Potter Farm beds are closely related to the Thunder Bay limestone, in which the evidence for a post-Hamilton age is somewhat clearer, and must be assigned to the same series as that formation.

Although no precise correlation is possible, the Potter Farm and Thunder Bay formations of the Alpena region are the approximate equivalents of the Petoskey formation of the type Traverse.

THUNDER BAY LIMESTONE

1841. C. C. Douglass, *Fourth Ann. Rept. State Geol.* (1840), *Mich. Legis. Doc.*, Vol. 1, p. 550.
1935. Partridge Point formation, Warthin and Cooper, *Jour. Washington Acad. Sci.*, Vol. 25, p. 525.

Although the Thunder Bay is the first formation named from the Alpena region most authors have overlooked its description, which was pointed out to the writers by G. M. Ehlers. Grabau[31] used the term "Thunder Bay" for a series comprising all the Traverse rocks above the Alpena limestone, leaving Douglass' original beds without any specific name. The writers at one time proposed the term "Partridge Point" for the exact sequence described by Douglass, but this name, together with Grabau's "Thunder Bay series" should be abandoned in favor of the earlier usage of the name.

The type locality of the formation is given in the original description as "the south cape of Thunder Bay." This is not South Point, near the Alpena-Alcona County line, but Partridge Point, about 3 miles south of Alpena. The cliff which contains the outcrop (locality 35) is on the east shore of the point near its tip, where the following section is visible.

	Thickness *Feet*	*Inches*
Glacial lake deposits		
Thunder Bay limestone		
4. Limestone, gray, irregularly bedded, weathering to a buff color	2	
3. Shale, gray, calcareous, with limestone lenses, becoming predominantly granular limestone at top	7	6
2. Covered interval	3	
1. Limestone, bluish, argillaceous, weathering to a rusty brown color; to lake level	1	

The calcareous shale yields many fossils, and from it have been described many species of Bryozoa and blastoids.

The Thunder Bay limestone forms small ledges in the fields just northwest of the center of Sec. 17, T. 31 N., R. 8 E., Alpena County, and beds which may be correlated with this formation crop out on the beach north of Norwood, Charlevoix County (locality 7c).

It is difficult to correlate this formation with the Devonian of New York. Together with the closely related Potter Farm formation below it must be as-

[31] A. W. Grabau, *op. cit.*, p. 192.

signed to some post-Ludlowville age. It is overlain, after a short covered interval, by the Squaw Bay limestone which is undoubtedly Upper Devonian, probably lower Portage (Genundewa) in age. The Thunder Bay and Potter Farm formations must then be equivalent to part or all of the Moscow-Tully-Geneseo of New York. Because of the great difference in lithologic facies little resemblance should be expected in the fossils of the New York and Michigan beds. Those resemblances which can be recognized point toward, but do not prove, a Tully age for the Potter Farm and Thunder Bay formations. The Thunder Bay beds show some similarity in fauna to the upper Cedar Valley limestone of Iowa, as pointed out by M. A. Stainbrook.[32]

SQUAW BAY LIMESTONE

1935. Warthin and Cooper, *Jour. Washington Acad. Sci.*, Vol. 25, p. 525.

The Squaw Bay shore of Partridge Point on Lake Huron (locality 54) has been chosen as the type locality. At the higher stages of Lake Huron the outcrop is covered by the waters of the lake, but at low levels the following section is visible.

	Thickness Feet
Lake deposits	
Squaw Bay limestone	
3. Limestone, brown, crystalline, irregularly dolomitic	3
2. Covered interval to east end of Partridge Point; estimated at	5
Thunder Bay limestone	
1. Limestone, gray, irregularly bedded	

The most significant fossils of the formation are cephalopods, which include *Tornoceras uniangulare* (Conrad), *Koenenites cooperi* Miller and *Bactrites warthini* Miller. Some layers of the limestone are made up almost entirely of the shells of *Styliolina fissurella* (Hall), all oriented with long axes in the same direction. The same orientation is commonly found in the shells of *Bactrites* and in the more elongate pieces of poorly preserved fossil wood common in the formation.

This formation also crops out at the center of Sec. 17, T. 31 N., R. 7 E., Alpena County, in association with the Thunder Bay limestone. This is probably the locality known to Grabau, who announced in an abstract[33] the discovery of Upper Devonian cephalopods in the Traverse, but later[34] stated the fauna was in the base of the Antrim black shale. These cephalopods have not been found by the writers in any layer above the Squaw Bay.

Oil is produced commercially from this zone in the "Saginaw sand," a name early given to the uppermost Traverse "pay" in several pools in the eastern and central parts of the Michigan basin.

[32] *Kansas Geol. Soc. Guidebook 9th Ann. Field Conference* (1935), p. 260.

[33] A. W. Grabau, "Notes on the Traverse Group of Michigan," *Science*, N. Ser., Vol. 28 (1908), p. 726.

[34] A. W. Grabau and H. W. Shimer, *op. cit.*, p. 631.

This formation is undoubtedly somewhat thicker than the type section indicates. In the record of a well drilled about 1.2 miles southwest of the type locality 12 feet of buff dolomite mark this horizon.

The goniatites and associated fossils indicate that the Squaw Bay limestone is Upper Devonian in age, probably with closest affinities to the Genundewa limestone of New York.

The subsurface occurrence of this formation has been described by Hake and Maebius,[35] who have also recognized units of gray, more or less calcareous shales beneath and above the Squaw Bay limestone. These they have termed the "Upper shale unit" and the "Overlying transition zone." They recognize the first of these, with a thickness of about 70 feet, in an Alcona County well only 25 miles distant from Partridge Point. At the outcrops on that point this unit can not be recognized, and its position is in doubt. The covered interval (bed 2) of the Squaw Bay limestone section appears to be too small to enclose this shale mass. This interval actually covers a surface distance of about $\frac{1}{3}$ mile between definite outcrops. On a basis of the regional dip alone there might be 14 feet of rock concealed there, but a probable low fold reduces the estimated thickness to about five feet in this interval.

There is some possibility that the 70 feet of "Upper shale unit" in Alcona County may thin sufficiently by convergence and overlap (both of which may be expected to exist here) to fit in this covered interval between the Squaw Bay and Thunder Bay limestones. The odds in favor of such a possibility are somewhat improved by a further examination of the previously mentioned Alcona County well log. If the bed below the "Upper shale unit" is assumed to be the Thunder Bay limestone it is possible to recognize in the log the proper thickness and lithology not only for that formation but also for the underlying Potter Farm and Norway Point beds.

The top of the Traverse group is usually recognized as the top of the highest Devonian limestone in Michigan. This would exclude from the Traverse group the "Overlying transition zone" of shale, although this shale is probably closely related to the limestone in age and areal distribution. Since the top of this zone is not easy to recognize in outcrops or well logs no useful purpose is served by including it in the Traverse group, and it seems wisest to continue the practice of identifying the top of that group with the top of the Squaw Bay limestone.

[35] B. F. Hake and J. B. Maebius, *op. cit.*, pp. 456–57.

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VOL. 27, NO. 5 (MAY, 1943), PP. 596-607, 2 FIGS.

SUBSURFACE STRATIGRAPHY AND LITHOLOGY OF TUSCALOOSA FORMATION IN SOUTHEASTERN GULF COASTAL PLAIN[1]

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ABSTRACT

The Tuscaloosa formation, which has, in the past, been classified both as Upper and as Lower Cretaceous, is examined from the subsurface viewpoint. The study was accomplished by means of deep wells located in South Carolina, Georgia, Florida, and Alabama.

Cuttings, cores, and log records seem to indicate the presence of a hitherto undetected marine zone within the Tuscaloosa. This zone is traced by lithologic changes and faunal content throughout the area mentioned. It is further suggested that the presence of this zone may account for the unsatisfactory determination of the stratigraphic position of the Tuscaloosa in eastern Georgia and South Carolina.

INTRODUCTION

The stratigraphic interrelationships of the Tuscaloosa formation at the base of the exposed Mesozoic section in the southeastern United States have long been of great interest to geologists. Many questions about equivalency and conditions of deposition of the Tuscaloosa still remain unsolved, principally because of inadequate subsurface information. The purpose of the present contribution is to add a few data which, it is hoped, will aid in the eventual solution of the problems.

The writer wishes to thank J.G. Lester for preparing several of the diagrams and critically reading the manuscript.

GENERAL FEATURES OF TUSCALOOSA

Named originally by Smith and Johnson[3] from beds typically developed in the vicinity of Tuscaloosa, Alabama, the Tuscaloosa formation was doubtfully placed in the Cretaceous at their suggestion. Three years later Langdon[4] proposed to include in the Tuscaloosa certain beds occurring in the region near Columbus, Georgia. Then, in 1911, Veatch and Stephenson,[5] and in 1914, Stephenson[6] presented evidence based on lithology which suggested a Lower Cretaceous age for some of the beds described by Langdon. Berry,[7] who examined several impressions of fossil leaves from these strata was inclined to concur in the opinion that the beds were Lower Cretaceous in age.

[1] Manuscript received, September 3, 1942.

[2] Assistant professor of geology.

[3] Eugene A. Smith and L. C. Johnson, "Tertiary and Cretaceous Strata of the Tuscaloosa, Tombigbee and Alabama Rivers," *U. S. Geol. Survey Bull. 43* (1887), pp. 71–138.

[4] D. W. Langdon, "Variations in the Cretaceous and Tertiary Strata of Alabama," *Bull. Geol. Soc. America*, Vol. 2 (1890), pp. 587–606.

[5] Otto Veatch and L. W. Stephenson, "Geology of the Coastal Plain of Georgia," *Georgia Geol. Survey Bull. 26* (1911), pp. 73–77, Pl. V.

[6] L. W. Stephenson, "Cretaceous Deposits of the Eastern Gulf Region," *U. S. Geol. Survey Prof. Paper 81* (1914), pp. 10–11.

[7] E. W. Berry, "Upper Cretaceous Floras of the Eastern Gulf Region in Tennessee, Mississippi, Alabama, and Georgia," *ibid., Prof. Paper 112* (1919).

Further mapping in the Alabama areas, however, convinced Stephenson[8] of the Upper Cretaceous age of these strata, with the result that they were correlated with the Tuscaloosa farther west in Alabama. This correlation extended the Tuscaloosa into west-central Georgia.

The removal of these beds from the Lower to Upper Cretaceous consequently made it necessary to re-examine the beds of eastern Georgia and South Carolina with which they had once been correlated. Cooke[9] made the field study, concluding that the basal beds properly belonged to the Upper Cretaceous. At the same time, he thought there were sufficiently diverging characteristics to warrant the establishment of a separate formation for which he proposed the name "Middendorf." Later work in the area convinced Cooke[10] that the Middendorf was the time equivalent of the Tuscaloosa, with the result that the name "Middendorf" was abandoned in favor of "Tuscaloosa" for the South Carolina and eastern Georgia beds. Cooke emphatically states however: "it is possible that beds older than the Tuscaloosa formation may some day be differentiated from these deposits in North Carolina and South Carolina."

The Tuscaloosa, therefore, as now defined, underlies the Eutaw formation and rests unconformably on the crystalline rocks of the Piedmont in Georgia and South Carolina, and on Paleozoic rocks in Alabama. Maximum development of the formation is attained in the type locality where its thickness has been estimated by Stephenson and Monroe[11] to be on the order of magnitude of 1,000 feet. The formation thins in a rather short distance, on the outcrop, toward the east; in Georgia and South Carolina, approximate measurements indicate a thickness between 350 feet and 400 feet.

SUBSURFACE STRATIGRAPHY

The partly anomalous stratigraphic position of the Tuscaloosa formation suggested that an investigation of the subsurface conditions might contribute some information to the solution of the problems. Some data were available from such scattered sources as well logs, well cores, and well samples from a few deep test wells in South Carolina, Georgia, Florida, and Alabama. Two wells are located in South Carolina, one in Georgia, two in Florida, and two are in eastern Alabama (Fig. 1). It is unfortunate that a greater number of well records are not available for study, but the interpretations herein submitted are thought to be rather well substantiated by the evidence. The diagrammatic cross sections (Fig. 2) illustrate the relations of the several beds within the Tuscaloosa.

[8] L. W. Stephenson, "Geology of Alabama—The Mesozoic Rocks," *Alabama Geol. Survey Spec. Rept. 14* (1926), p. 234.

[9] C. W. Cooke, "Correlation of the Basal Cretaceous Beds of the Southeastern States," *U. S. Geol. Survey Prof. Paper 140* (1926), pp. 137–39.

[10] C. W. Cooke, "Geology of the Coastal Plain of South Carolina," *ibid.*, *Bull. 867* (1936), pp. 17–19.

[11] L. W. Stephenson and Watson H. Monroe, "Stratigraphy of the Upper Cretaceous Series in Mississippi and Alabama," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 22, No. 12 (December, 1938), p. 1641; Fig. 2, p. 1642.

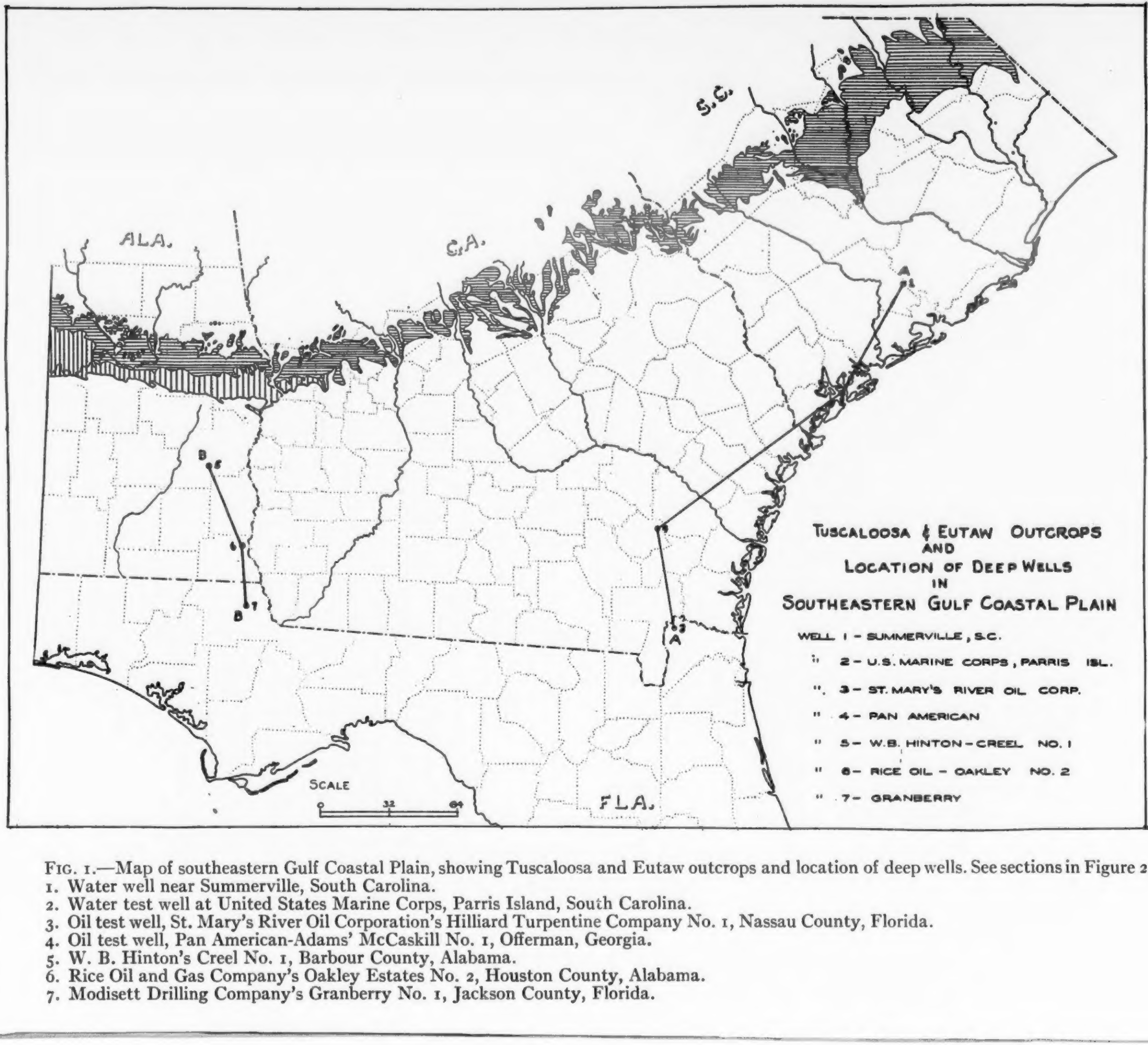

FIG. 1.—Map of southeastern Gulf Coastal Plain, showing Tuscaloosa and Eutaw outcrops and location of deep wells. See sections in Figure 2.
1. Water well near Summerville, South Carolina.
2. Water test well at United States Marine Corps, Parris Island, South Carolina.
3. Oil test well, St. Mary's River Oil Corporation's Hilliard Turpentine Company No. 1, Nassau County, Florida.
4. Oil test well, Pan American-Adams' McCaskill No. 1, Offerman, Georgia.
5. W. B. Hinton's Creel No. 1, Barbour County, Alabama.
6. Rice Oil and Gas Company's Oakley Estates No. 2, Houston County, Alabama.
7. Modisett Drilling Company's Granberry No. 1, Jackson County, Florida.

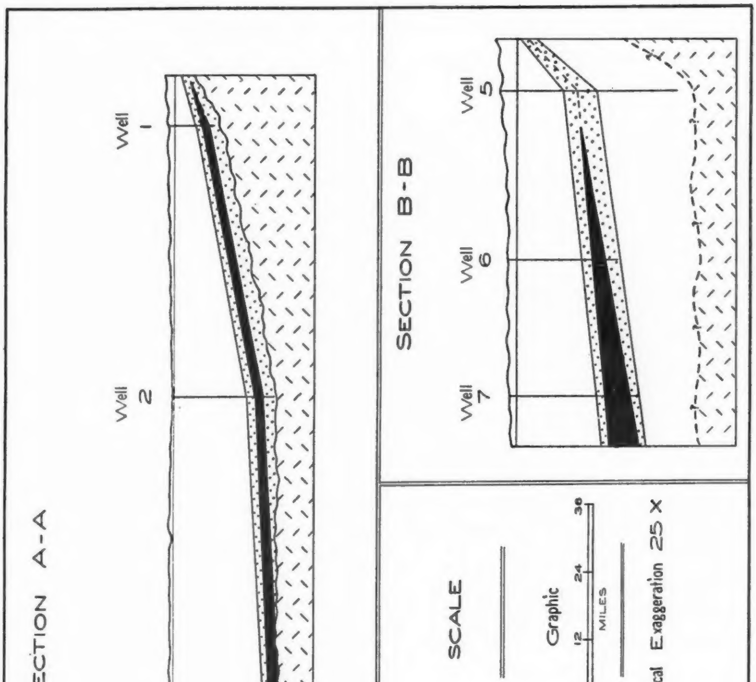

FIG. 2.—Diagrammatic cross sections showing theoretical relation of marine zone to non-marine phases of Tuscaloosa formation.

SOUTH CAROLINA

Cooke[12] has published the log of an oil-test well drilled in Dorchester County, near the town of Summerville (Fig. 1, well No. 1). A condensed version of this log is as follows.

	Depth in Feet
Duplin marl	5–8
Hawthorne	37½
Eocene (Cooper marl and Santee limestone)	313
Upper Cretaceous (Peedee and possibly Tuscaloosa)—chiefly dark gray, gritty clay and marl; fragments of *Inoceramus* and *Belemnitella* found below 700 feet probably came from this interval	700
No record	727
Coarse quartz sand	744
Gray or rusty sand; lignite at base	1,580
Upper Triassic(?) (Newark group?)	
Coarse reddish sand; greenish clay and pyrite from core at 1,613 feet	1,630
Diabase	1,645
Reddish shale and sandstone; poorly rounded pebbles at base	2,002
Chiefly pinkish sand and gravel; gray clay from bit at 2,193 feet and red clay at 2,208 feet	2,450
Diabase	2,570
Total depth	2,570

Although Cooke points out that the Upper Cretaceous is not definitely recognizable in this record, it seems entirely possible that the interval from 744 to 1,580 feet contains beds which are at least time equivalents of the Tuscaloosa. Added support to this supposition is given by the presence of lignite at a depth of approximately 1,580 feet, because it seems likely that organic material would be contained in the lowermost beds of a formation partly deposited by a sea encroaching upon a landmass covered with luxuriant vegetation. Furthermore, as the water became progressively deeper, the sediments should reflect the change and show, increasingly, more and more typical marine characteristics. This seems to be the case in the section penetrated by the Summerville well, although there is no definite evidence that the Tuscaloosa is or was ever present in this area.

Another well (Fig. 1, well No. 2) located on Parris Island in Beaufort County, drilled as a water well for the United States Marine Corps in 1940, reached a depth of 3,454 feet. It probably encountered the top of the Tuscaloosa at 2,669 feet and penetrated 785 feet of that formation below that point. A partial log of this well showing the lower section is here given.[13]

	Depth in Feet
Eutaw	
Light greenish gray, micaceous, sandy clay; fine-grained sand and small brown concretions	2,649–2,669
Tuscaloosa	
Light greenish gray, micaceous, sandy clay; coarse sand	2,704
Purple and yellowish green sandy clay and mica; coarse to fine sand, and weathered feldspar	2,726
Very coarse gray sand and weathered feldspar	2,738

[12] C. W. Cooke, "Geology of the Coastal Plain of South Carolina," *U. S. Geol. Survey Bull. 867* (1936), pp. 176–77.

[13] Log prepared by W. McGlamery, Alabama Geol. Survey, 1940.

	Depth in Feet
Dark purple clay and coarse sand	2,755
Very coarse, greenish gray, micaceous, sand and pebbles	2,775
Same, with weathered feldspar	2,808
Dull purplish sandy clay and coarse sand	2,810–2,832
Light greenish gray, micaceous, coarse sand	2,846
Same, with purplish clay	2,866
Purplish, sandy, micaceous clay	2,887
Dark purple clay and coarse-grained, greenish gray, micaceous sand	2,888–2,909
Same, sand finer-grained	2,929
Light green, coarse-grained, micaceous sand	2,945
Micaceous, purplish clay	2,965
Light green, coarse-grained, micaceous sand	2,986
Very coarse-grained, light greenish gray sand and purple clay	3,007
Greenish gray, medium- to fine-grained, micaceous sand	3,027
Same, but coarse-grained	3,056
Same, with variegated sand	3,070
Same	3,084
Dark red clay, and greenish gray, micaceous sand	3,097
Dark red and green mottled clay	3,117
Greenish, carbonaceous clay and coarse sand	3,137
Medium- to coarse-grained, greenish, micaceous sand, and purple and red sandy clay	3,149
Glauconitic, micaceous, sandy, fossiliferous marl; small sand lenses, and carbonaceous material	3,169
Greenish, glauconitic, micaceous shale, and small sand lenses; very fossiliferous (pelecypods and ostracods)	3,178
Indurated sandy marl; carbonaceous material; many shell impressions and fragments	3,194
Greenish, carbonaceous clay and small sand lenses with mica	3,211
Green, sandy marl; mica and glauconite; many shell fragments (Bryozoa and gastropods); some carbonaceous material	3,232
Greenish gray shale; micaceous, glauconitic sand lenses; pyrite	3,248
Green and brown mottled, micaceous, carbonaceous clay and sand lenses	3,262
Greenish gray, coarse, micaceous sand; weathered feldspar	3,268–3,307
Greenish, medium-grained, micaceous sand with red streaks	3,326
Coarse sand and mica; green and reddish clay	3,335
Green and red mottled sand with mica	3,355
Greenish, coarse, soft sand	3,375
Dark red and green mottled clay	3,395
Greenish, coarse, variegated sand and gravel; some weathered feldspar	3,435
Same, with mica, some pink quartz noted	3,454
Total depth	3,454

It will be noted in the above log that the upper part of the Tuscaloosa (2,669–3,149 feet) consists of light green, gray, purple and red, arkosic sand and clay. This lithologic character strongly suggests that either continental or extremely shallow marine conditions of deposition were present in this area during the beginning and early part of Tuscaloosa time in which the volume of alluvium greatly exceeded the sorting capacity of the encroaching sea. The absence of fossils supports this viewpoint. On the other hand, the 99-foot interval between 3,149 and 3,248 feet is occupied by completely different beds containing recognizable fossils.

The fossiliferous beds are marly, carbonaceous, and glauconitic, indicating typical marine conditions of deposition for this zone. Although the relationship is not determinable, it is assumed that the marine zone is conformable with the overlying "red" beds, one grading imperceptibly into the other.

Lying below the marine beds is a section 206 feet thick (3,248–3,454 feet) consisting of vari-colored, coarse, micaceous, arkosic sand and clay which is very similar to the sediments observed in the section above the marine beds. The relation to the marine beds is probably the same as that of the upper zone.

Thus the probable sequence of events which occurred in this area during Tuscaloosa time was, first, a gradual encroachment of a shallow sea upon a deeply weathered landmass of which the present Piedmont is a part. The residual mantle rocks were partly reworked by the shallow water, but not enough to destroy their continental characteristics. Second, a gradual deepening of the sea, due to further encroachment, introduced more and more typical marine conditions and permitted marine organisms to invade the area. And lastly, stream rejuvenation, due to uplift of the landmass or a retreat of the sea, re-introduced conditions which simulated those of the early Tuscaloosa, forming deposits predominantly of a continental type.

GEORGIA

Wells drilled in Georgia have not as a rule penetrated to the base of the Mesozoic section because the majority have been put down in search of water which occurs at higher, and younger, levels. In recent years there has been considerable activity in prospecting for petroleum in Georgia, and several wells have been drilled through the Coastal Plain sediments into materials vastly older than them. One of these deep wells is located near Offerman, Pierce County (Fig. 1, well No. 4). It was drilled by the Pan American Production Company in 1938, and designated the Pan American–Adams' McCaskill No. 1. The well reached a total depth of 4,375 feet, drilling operations being suspended when hard pink granite was encountered at that depth. The log of the lower part of this well is as follows.

	Depth in Feet
Tuscaloosa	
Coarse, variegated sand; pyrite	3,995–4,010
Same and coarse sand	4,040
Coarse, variegated sand, and dark gray shale	4,055
Light gray, micaceous, medium-grained sand	4,060
Same, with some clay	4,070
Light gray, coarse, micaceous, carbonaceous sand, and clay	4,085
Coarse, variegated sand; pyrite	4,100
Same; pyritized wood	4,115
Same	4,130–4,145
Same, pyrite and carbonaceous material	4,160
Same	4,175–4,190
Same	4,205
Same, medium-grained sand, and pyritized wood	4,220
Coarse, variegated sand, pyrite, and pyritized wood	4,235
Light to medium gray, hard, micaceous, sandy marl with glauconite; (ostracods and other imbedded marine shells)	4,238–4,243
Light gray, fine-grained, micaceous sand with glauconite, and medium gray, carbonaceous shale lenses	4,246–4,253
Same	4,250–4,265
Medium gray, indurated sandy marl; carbonaceous material; dark gray shale lenses; chert pebbles; mica; abundant shell fragments; ostracods	4,280
Same	4,295

	Depth in Feet
Same and sand	4,294–4,325
Light gray, fine-grained, micaceous, calcareous sand with glauconite; clay lenses; pyrite	4,340
Pink granite	4,355–4,375
Total depth	4,375

It is believed that the section from 3,995 to 4,375 feet includes all of the Tuscaloosa present at this location. It is obvious, though, that there are discrepancies when correlation is attempted with the Parris Island, South Carolina, well (Fig. 1, well No. 2). For example, the lowermost beds of the Georgia well are typically marine in character—hard, light gray sand, sandy glauconitic marl, and carbonaceous shale containing undescribed ostracods. This zone is overlain by coarse-grained, arkosic, varicolored sands and intercalated clay beds which probably represent the uppermost, continental zone of the Parris Island well. Therefore, the lowermost continental zone of the South Carolina well is not present at the Offerman location. The lack of sufficient information makes it impossible to determine whether these lower beds were once present, then removed by erosion at a later time, or whether the beds were never deposited. It seems more than likely that the latter possibility is the correct solution. It is suggested that the pink granite represents a small part of a resistant mass in the pre-Tuscaloosa landscape—a monadnock, in other words. Then, upon the encroachment of the Tuscaloosa sea, it existed as an island for some time, finally being buried by sediments as the sea became deeper and deeper.

FLORIDA

The St. Mary's River Oil Corporation well (Fig. 1, well No. 3) which has been discussed by Campbell[14] penetrated the Tuscaloosa and entered rocks probably Mississippian in age. The log of the lower part of this well follows.

	Depth in Feet
Sandy shale	4,260–4,266
Sand	4,283
Sandy shale	4,289
Black sandy shale	4,291
Clay and shale streaks	4,300
Sand, salt water	4,312
Sand	4,323
Sand and shark teeth, fossils	4,325
Shale	4,331
Shale and sand streaks	4,333
Sticky shale	4,375
Unreported	4,385
Sticky shale	4,435
Lime and pyrite; very hard	4,437
Light shale	4,461
Dark shale	4,463

[14] Robert B. Campbell, "Paleozoic under Florida?" *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 23, No. 11 (November, 1939), pp. 1712–13.

———, "Outline of the Geologic History of Peninsular Florida," *Proc. Florida Acad. Sci.*, Vol. 4 (1939), pp. 91–94.

	Depth in Feet
Shale with green streaks; lime shells	4,485
Light gray, sticky shale	4,515
Shale and a little sand	4,528
Sand	4,550
Sand and salt water	4,560
Dark shale	4,562
Heaving sand	4,587
Lime and gravel	4,588
Red sand, hard	4,595
Same	4,615
Purple sand rock	4,635
Base of Tuscaloosa?	
Black shale, very hard	4,730
Total depth	4,814

The St. Mary's well has been studied by several investigators who chose the top of the Tuscaloosa at the depth of 4,260 feet. Mrs. E.R. Applin, according to Campbell,[15] placed the top contact 177 feet below this level, or at 4,437 feet. The disagreement arises, perhaps, from the close lithologic similarity between the upper part of the Tuscaloosa and the lower beds of the Eutaw in this well. Inspection of the log shows that the vari-colored sands and clay of the upper Tuscaloosa, noted in the Georgia and South Carolina wells, are not present in this well. On the other hand, the marine beds are well developed, as are the continental-type beds which underlie them. It is probable that the marine zone of the St. Mary's well is correlative with the marine zone of the Offerman, Georgia, well. If this is true then somewhere between the two locations lies the position occupied by farthest seaward retreat of the sea in the mid-Tuscaloosa. This is substantiated by the absence of the upper continental zone in the Florida well, and its presence in wells northward or shoreward.

The second deep well of Florida, the Granberry, Jackson County (Fig. 1, well No. 7), which penetrated the Tuscaloosa, was reported by Cole[16] in 1938.

It penetrated 1,568 feet of a sedimentary section lying below the Tuscaloosa–Eutaw contact. A partial log of this well condensed from Cole's report follows.

	Depth in Feet
Coarse sandstone; ½-inch pebbles; carbonaceous material	3,472–3,477
Medium- to coarse-grained sandstone, micaceous, with red and brown shale	3,488–3,970
Gray to dark gray, medium-grained, micaceous sand	4,044–4,182
Mottled, reddish brown, micaceous, sandy shale, interbedded with gray, medium- to coarse-grained, micaceous sandstone	4,262–5,022

Cole[17] also presents a graphical log of the Granberry well which shows marked differences in the depositional regimes within the Tuscaloosa. A fairly thick section of shale is indicated between the approximate depths of 3,900 and 3,975 feet. Above this lies a series of beds containing considerable gravel and sand,

[15] Robert B. Campbell, *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 23, No. 11 (November, 1939), p. 1712.

[16] W. Storrs Cole, "Stratigraphy and Paleontology of Two Deep Wells in Florida," *Florida Dept. Cons. Geol. Bull. 16* (1938), pp. 19–36.

[17] W. Storrs Cole, *op. cit.*, Fig. 3, p. 20.

and below it are beds described as "red, micaceous, often lignitic shales, interbedded with gray, medium-grained sandstones." As there are no paleontologic reports on the Tuscaloosa in this well, it is impossible to confirm the existence of the marine zone as suspected.

ALABAMA

Several oil-test wells have been drilled in eastern Alabama in the past few years. Some of these might be of interest to this discussion because they are deep enough to have reached and penetrated most of the Tuscaloosa formation. In particular, Wm. B. Hinton's Creel No. 1, Sec. 14, T. 9 N., R. 26 E., Barbour County, shows a significant section. This well, with a casinghead elevation of 542 feet, was drilled to the total depth of 5,522 feet. It passed through an unduly thick section of sediments for its location, which is 15–20 miles south of the Fall Line. W. McGlamery, Alabama Geological Survey paleontologist, examined the cores and samples from this well and prepared a log of it. A part of this log follows (Fig. 1, well No. 5).

	Depth in Feet
Top of Tuscaloosa	
Medium- to coarse-grained, glauconitic sand; gray shale with ostracods	1,958–1,986
Medium- to coarse-grained, glauconitic, micaceous sand	2,017
Same with some shale	2,047
Gray, fine-grained, glauconitic, micaceous, fossiliferous sand, with pyrite; foraminifera	2,048–2,079
Medium- to coarse-grained sand; grayish shale and fragments of hard dark red and green shale	2,109
Gray, glauconitic, fine-grained, micaceous sand, with ostracods. *Hamulus* sp. fragments	2,140
Gray, micaceous sand and shale; shell fragments	2,233
Medium gray carbonaceous shale and shell fragments; sand	2,264
Coarse sand; gray, sandy, micaceous, fossiliferous shale with pyrite; siderite(?) concretions; shell fragments of *Hamulus*(?)	2,295
Coarse sand, greenish gray, micaceous, carbonaceous shale	2,326
Same shale as preceding; very coarse sand; white clay	2,357
Medium- to coarse-grained sand and glauconite; shell fragments	2,388
Medium-grained to coarse-grained sand and coarse glauconite; abundant shell fragments: foraminifera and ostracods	2,419
Coarse-grained, etched quartz and coarse glauconite; a few foraminifera	2,450
Fine- to coarse-grained, gray, micaceous, glauconitic, fossiliferous sand	2,481
Medium- to coarse-grained etched sand; fragments of gray carbonaceous shale	2,512
Coarse, glauconitic sand and gray shale; fragments of fine-grained, fossiliferous sandstone	2,543
Dark gray shale and glauconite; micaceous, sandy marl; ostracods	2,574
Medium gray, micaceous, carbonaceous sand	2,605
Hard, gray, micaceous, glauconitic sand; gray shale	2,636
Coarse- to medium-grained, micaceous, glauconitic sand and shale	2,667
Coarse-grained sand and fragments of green and purple clay; hard dark red shale	2,698
Coarse sand; purple, green and red clay and shale with coarse feldspar near bottom	3,000
Base of Tuscaloosa (?)	
Very much the same material, vari-colored	5,491
Weathered basic igneous rock—"probably olivine with serpentine"—(diabase?)	5,546
(Similar basic igneous rocks were later noted in cores from 5,342 to 5,372 feet)	

From the foregoing log the presence of a relatively thin marine zone separating two continental zones is not apparent. On the basis of the outcrop lithology, only

a few miles north, it seems improbable that the Tuscaloosa would be as thick as 1,000 feet at this locality. It is suggested, therefore, that the upper part of this zone may belong to the Eutaw, but just where the contact should be placed can not be determined. The beds below 2,667 feet probably include the marine zone, but it has not been detected due to the process of rotary drilling. The hypothetical relation of the beds penetrated by this well with the beds of the Granberry well is shown in Figure 1.

Direct confirmation of the existence within the Tuscaloosa formation of a true marine zone was supplied by the observations of Stephenson and Monroe[18] upon an outcrop in central Alabama. They state:

> The only invertebrates recorded [in the Tuscaloosa] are some poorly preserved prints of *Ostrea* and *Modiolus* found near the middle of the formation at one locality in Chilton County [Alabama]; these and the presence of glauconite indicate the deposition of the containing bed and associated beds in shallow marine and brackish water.

A second well in Alabama (Fig. 1, well No. 6), drilled by the Rice Oil Company in 1938, to the total depth of 5,214 feet, apparently confirms the presence of the three facies of the Tuscaloosa. A condensation of a driller's log, not substantiated by sample or core examination, follows.

	Depth in Feet
Salt water sand	3,035–3,065
Sticky shale, red	3,126
Sand	3,146
Sticky red shale	3,174
Sand	3,270
Red sand	3,290
Hard lime(?)	3,292
Red sand	3,316
Hard red shale	3,319
Sand	3,356
Shale	3,387
Red shale and sand	3,425
Sand	3,500
Sandy shale	3,580
Sticky shale	3,620
Alternating sand and sandy shale	3,865
Sandy clay and shale	4,002
Shale, streaks of sandy shale and ash(?)	4,562
Red sticky shale, and sandy ash(?)	4,885
Sand and ash(?)	4,900
Sticky shale and streaks of hard lime(?)	5,190
Hard lime	5,214
Very hard lime—"called Paleozoic by paleontologist"(?)	

If the depth of 3,065 feet in this well represents the top of the Tuscaloosa, it can be seen that there is a zone of vari-colored beds from that point down to 3,425 feet. Furthermore, increasing depth shows progressively finer material, that is, sandy shale and "sticky" shale. This is followed, at greater depth, by alternating beds of shale and sand whose color seemingly was not noteworthy. It may be inferred, therefore, that these beds are not highly colored by reddish

[18] L. W. Stephenson and Watson H. Monroe, "Stratigraphy of the Upper Cretaceous Series in Mississippi and Alabama," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 22, No. 12 (December, 1938), p. 1653.

and brownish hues and may be, then, of the duller colors such as might be expected in marine sediments. Beneath this zone, at the depth of 4,562 feet, red-colored shales and sands reappear, associated with an indeterminate substance referred to as "ash." If these inferences are correct, the three zones of the Tuscaloosa are probably present in this well. The position of this well in relation to the Granberry well and Wm. B. Hinton's Creel No. 1 is illustrated in Figure 2.

CONCLUSIONS

The logs of deep wells apparently indicate the presence of a marine zone within the Tuscaloosa which can be recognized throughout a wide area of the southeastern Gulf Coastal Plain. At the beginning of Tuscaloosa time a shallow sea encroached upon a deeply weathered landmass at the north, partly reworking the accumulated subaerial detritus into a vari-colored series of beds. Continued advance of the sea, with increased depth of water, brought more typical marine environments farther northward. Marine organisms and better sorting of sediments accompanied the greater depth of water, with the result that quite different rocks were formed. This phase was followed by a retreat of the sea southward, and (or) an uplift of the landmass with consequent rejuvenation of streams, vari-colored beds of the continental type being the result. A second advance of the sea inaugurated the Eutaw.

From the evidence submitted there seems to be little opportunity for noting the possible occurrence of Lower Cretaceous beds. The writer believes that much of the past confusion in the correlation of the basal beds of the eastern Gulf Cretaceous may be due to the presence of the discussed marine zone.

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VOL. 27, NO. 5 (MAY, 1943), PP. 608-621, 5 FIGS.

STRATIGRAPHY AND AGE OF SEGUIN FORMATION OF CENTRAL TEXAS[1]

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ABSTRACT

Evidence from four localities in central Texas indicates that the Seguin formation as originally defined straddles the boundary between the Midway and Wilcox groups of the Eocene. The members of the Seguin formation, the Solomon Creek clays and the Caldwell Knob sands, are redefined so that the base of the Wilcox group is placed at a disconformity marking the top of the Solomon Creek clays and the base of the Caldwell Knob sands.

The Seguin formation, basal Wilcox of Texas, as proposed by F. B. Plummer (1932, p. 674) included those strata lying between the top of the compact silty clays of the Midway and the base of the non-marine Rockdale formation. The type locality was stated to be the exposures along the banks of Moss Branch 10 miles northwest of Bastrop, Bastrop County, Texas.

The formation was divided into two members, the Solomon Creek below and the Caldwell Knob oyster bed above. The type locality of the first is along Solomon's Creek 6 miles southwest of Elgin. The type locality of the Caldwell knob member is at Caldwell Knobs which lie high on the banks of Moss Branch along which is also exposed a part of the Solomon Creek beds. The beds along Solomon's Creek were correlated with fossiliferous sands and clays exposed at Smiley's Bluff on the Brazos River by Julia Gardner (1933, p. 54) in her paper on the Midway group of Texas. By this correlation the beds at Smiley's Bluff would be considered Seguin. These beds and fossils had been examined previously by Harris (1895, p. 45) who considered them to be Midway in age and synchronous with the beds at Matthew's Landing in Alabama. William Kennedy (1895, p. 146) at about the same time described the section at Smiley's Bluff and stated that the beds here were probably the uppermost beds belonging to the Basal clays (Midway) and that a bed near the top represented a transition between the "Basal Clays" and the overlying "Lignitic" (Wilcox).

A study of the Wilcox fauna of Texas was made by Chester Claypool (1933, p. 1) with the purpose of stratigraphically subdividing the Wilcox group. After studying the fauna of the Wilcox of Texas he made a tentative correlation of the central Texas section with sections found in the other Gulf Coast states. He

[1] Manuscript received, August 15, 1942.

After the manuscript was submitted for this paper, a paper entitled "Lower Eocene Faunal Units of Louisiana," *Geological Bulletin 23*, was written by J. O. Barry and R. J. LeBlanc and published by the Louisiana Geological Survey.

The Solomon Creek member as defined herein apparently corresponds to the upper part of the Hall Summit unit of Barry and Le Blanc while the Caldwell knob member may be correlated with the basal sand member of the Marthaville unit and the beds containing *Ostrea thirsae* in association with *O. multilirata*.

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decided that the Seguin formation corresponded with the Ackerman of Mississippi and the "Coal Bluff" beds of Alabama, which are placed at the base of the Wilcox group. In another statement, however, Claypool declares that "It is the writer's belief that the Seguin, Ackerman and 'Coal Bluff' beds may more properly belong in the Midway Group."

Helen Jeanne Plummer (1933, pp. 51–68) has studied the Midway–Wilcox contact and published an excellent discussion of the contact between the Solomon

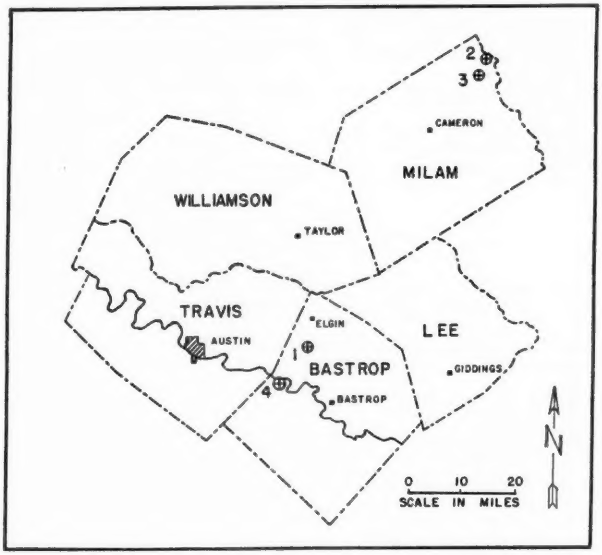

FIG. 1.—Sketch map, showing locations of stratigraphic sections. 1, Solomon's Creek section. 2, Smiley's Bluff section. 3, Pearson's Branch section. 4, Moss Branch section.

Creek beds and the dense foraminifera-bearing clays of the Wills Point-Midway below. For purposes of subsurface correlation this seems to be the most satisfactory datum that can be determined in this part of the section.

Recent observations by the writers indicate that there is a disconformity within the Solomon Creek member of the Seguin formation as originally defined and that the beds below the disconformity are Midway in age and those above are Wilcox in age and that the Midway–Wilcox contact is correct as placed by Kennedy in 1895.

DESCRIPTION OF SECTIONS

Detailed sections were measured at Smiley's Bluff, Solomon's Creek, Pearson's Branch, and Moss Branch. The geographic positions are shown in Figure 1.

SOLOMON'S CREEK SECTION

		Feet
Solomon Creek member		
T.	Sand, gray, medium-grained, with rippled stringers of clay	10.5
S.	Sand and clays, buff to gray, containing fossiliferous concretions	7
R.	Sand concretions, buff, flat, laminated	11
Q.	Clay and silt interbedded	7.5
P.	Silt, concretionary in places	1
O.	Clay, silty, laminated. (Contains bed of *Turritella polysticha*.)	11
N.	Sand, concretionary, wavy, cross-bedded with a few fossils	2
M.	Silty clay, gray, gypsiferous, copiapite on bedding planes	3
L.	Sand concretions, gray, rough surface, with few fossils	2.7
K.	Silts and clays interbedded, laminated, silts show channeling	13.5
J.	Silts, micaceous, weather brown	0.5
I.	Silts and clays interbedded, laminated, with marcasite concretions	2
H.	Bed of *Teredo* borings	1
G.	Clay, silty, gray, laminated, with carbonaceous fragments	4.8
F.	Sand concretions, brown, flat, irregularly shaped, concretions have a few fossils	2
E.	Silts and clays interbedded, fossiliferous, micaceous	4.8
D.	Calcareous sand concretions, reddish brown, flat, irregularly shaped	0.8
C.	Silts and clays, gray, fossiliferous, with carbonaceous fragments	7
B.	Silty clay, laminated with carbonaceous fragments; has copiapite along bedding planes	6
		98.6
Kerens member		
A.	Clay, black to gray, fossiliferous, compact, weathers light gray	

The base of the section (Bed A) consists of dark compact clays containing a Wills Point fauna (Fig. 2.) These dark clays grade upward into more silty clay accompanied by a gradational faunal change. This faunal and lithological change is recognized as the line between the Kerens member of the Wills Point formation and the Solomon Creek member of the Seguin formation.

The Solomon Creek member consists of laminated, interbedded silts, sands, and clays, containing fragmental carbonaceous material. Prominent concretionary ledges of sandstone occur throughout the section. The concretions exhibit cross-bedding, laminations, and fretted surfaces.

A log-shaped mass of *Teredo* borings protrudes from the bank of Solomon's Creek in the lower part of the section (Bed H). The silts immediately above the *Teredo* borings are characterized by small, knobby marcasite concretions. Bed L is a zone of large flat concretions which weather out and cover the creek bottom. A bed of *Turritella* and other fossils is about 4 feet above this concretionary zone.

The lower 88 feet of the section has the typical Solomon Creek lithologic character; however, in Bed S there is a transition upward to a more sandy phase. Highly fossiliferous, concretionary boulders occur in this bed. The Caldwell knob member is not recognizable in this section.

SMILEY'S BLUFF SECTION

The Smiley's Bluff section is an exposure along the Brazos River in northeast Milam County. It is located on Oliver Wall's Ranch near Baileyville and is as follows, from the top downward.

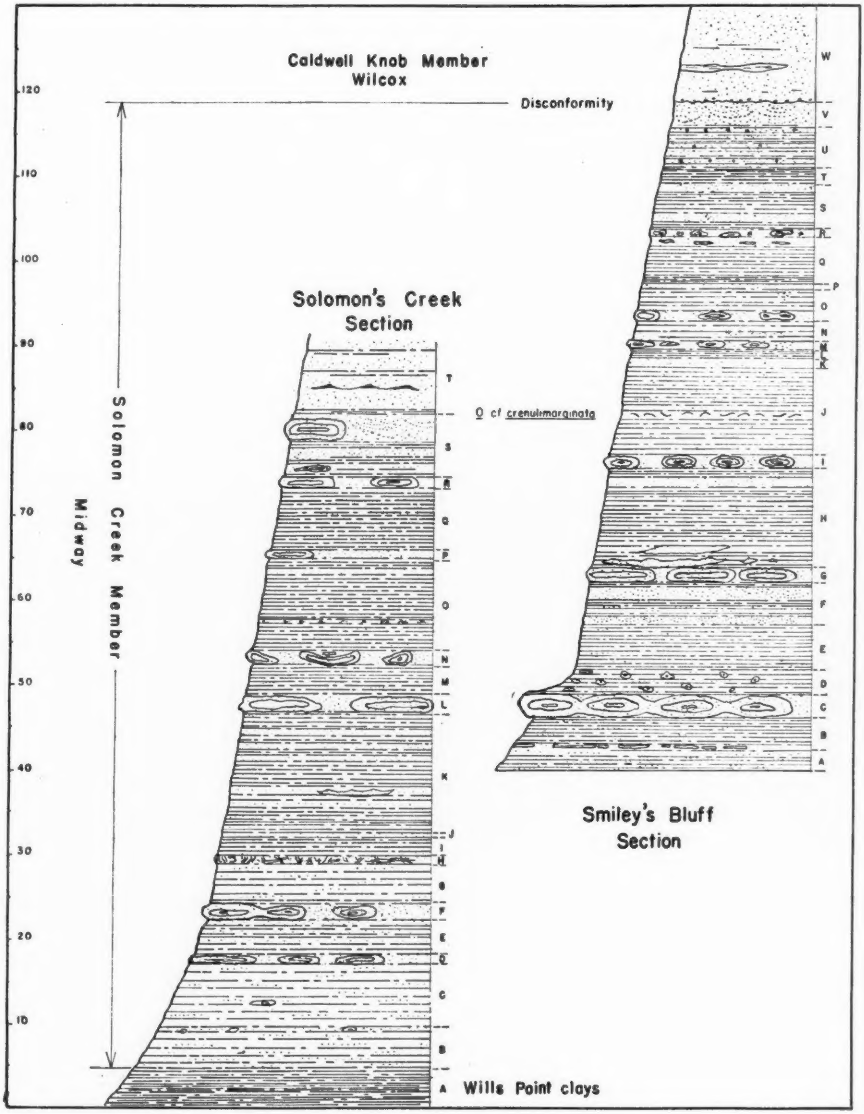

FIG. 2.—Solomon's Creek section and Smiley's Bluff section.

		Feet
Caldwell Knob member		
W.	Sand, buff, medium-grained, cross-bedded, shale pebbles and lenses at bottom, concretionary near top	11.7
Disconformity		
Solomon Creek member		
V.	Silt, gray to dark, cross-bedded, contains considerable carbonaceous fragments	3
U.	Clay, interbedded with very fine-grained sand, marcasite concretions	6.8
T.	Clay, dark to light gray, finely laminated, fossiliferous	2
S.	Clay, interbedded with very fine-grained, cross-bedded sand; with marcasite concretions	5.5
R.	Sand, gray, very fine-grained, cross-bedded; with marcasite concretions	5
Q.	Clay, interbedded with silts; marcasite concretions. Thin layer of limestone concretions near top	6
P.	Sand, dark, very fine-grained, laminated	0.5
O.	Silt, interbedded with clay, a cross-bedded layer of large oval concretions at base	4
N.	Silt, interbedded with clays, cross-bedded; between two prominent concretionary layers	2
M.	Sand, concretionary. Cross-bedded; oval concretions	1
L.	Silt, gray, cross-bedded, interbedded with dark shale	1
K.	Sand, gray, very fine-grained, laminated, micaceous	1
J.	Clay, dark, interbedded with laminated, cross-bedded gray sand	10
I.	Sand, very fine-grained with large, flat, fossiliferous concretions	1
H.	Silt interbedded with clay, ripple-marked	13
G.	Sand, concretionary, cross-bedded, large, flat concretions	1
F.	Silt interbedded with dark clay, fossiliferous	4
E.	Clay, silty, gray, laminated, fossiliferous	4
D.	Silty clay, gray, fossiliferous, contains very irregularly shaped ferruginous concretions	4.75
C.	Sand, concretionary ledge, fossiliferous	3
B.	Clay, black, silty, fossiliferous. Contains 2-inch bed of concretionary clay-ironstone at base	3.18
A.	Sand, buff, fine-grained, gypsiferous; with carbonaceous fragments	3+
		89.23

The lower part of the section is characterized by interbedded clays and silts with prominent concretionary layers at irregular intervals.

One of the most conspicuous features is the large concretionary ledge (Bed C) a few feet from the base of this section (Fig. 2). The silty clays below this large ledge are fossiliferous although few fossils were collected because of the high water of the Brazos River in 1940 and 1941. Bed D, which is characterized by irregularly shaped ferruginous concretions, contains many of the fossils discussed under "Paleontology."

The section above this consists of interbedded clays and cross-bedded silts with some ripple-marks. A thin bed of oyster shells, water-worn gastropods, shark teeth, and carbonaceous fragments is approximately 33 feet above the concretionary ledge.

The section above the oyster bed consists of interbedded clays and cross-bedded silts with silts predominating near the top; Bed V is composed entirely of silt. Many silt beds have knobby marcasite concretions. The cross-bedding planes are outlined by carbonaceous fragments. Fossils have not been found higher than Bed T, which has a considerable number of pelecypods.

A distinct lithological break occurs 11.7 feet from the top of the section. The change of deposition from the laminated clays and silts to massive, gray sand marks the dividing line between the Solomon Creek member and the Caldwell

Knob member. The base of the Caldwell Knob member exposed at Smiley's Bluff is recognized by a basal conglomerate of clay pebbles in massive sand. Wavy stringers of clay are characteristic of the lower sands of this member. This contact can be traced across country to Pearson's Branch.

PEARSON'S BRANCH SECTION

The Pearson's Branch section is exposed along Pearson's Branch which heads on the Sneed Ranch south of Pond Creek in northwest Milam County (Fig. 3). The section is as follows, described from the top downward.

	Feet
Rockdale formation	
J. Sand, gray, with streaks of clay	2+
Caldwell Knob member	
I. Clay, sandy, calcareous, shows concretionary tendency. Equivalent to reef of *Ostrea multilirata* var. *duvali* Gardner near river	1
H. Clays and sands, interbedded	5
G. Sandy limestone, brown, cone-in-cone structure	1
F. Clay and silt, laminated. Unctuous clay grades into cross-bedded silts near top of bed	28
E. Clay and sand, with carbonaceous fragments. Oyster casts	2
D. Lignite	0.18
C. Clay, unctuous, laminated	0.83
B. Sand, gray, medium-grained, cross-bedded; with large brown concretions 32 feet from base. Characteristic ledge	47
Disconformity	
Solomon Creek member	
A. Silty clay, gray, unctuous, laminated	5
	92.9

The disconformity described in Smiley's Bluff section is exposed near the base of this section. The beds below the disconformity are massive cross-bedded sands. Streaks of limonite are common along bedding planes in the sand. About 30 feet above the disconformity the sand is consolidated into large, flat, brown, concretionary masses with calcareous cement. The sands above this brown concretionary ledge contain thin streaks of unctuous clay.

Bed C, approximately 15 feet above the brown concretionary bed, marks a change in deposition. This clay bed is overlain by a thin bed of lignite. Bed E is composed of both sand and clay with carbonaceous matter and contains impressions of oyster shells which have been leached. A stratified unctuous clay, which grades upward into silt with streaks of clay, lies directly above Bed E.

Bed G, which is found 30 feet above the thin lignite bed, is a ledge-forming arenaceous limestone with cone-in-cone structure remarkably developed. This non-fossiliferous limestone grades laterally into brown sandstone. Five feet of the section above this limestone consists of interbedded clays and silts.

Bed I is calcareous concretionary clay. This was traced over from an outcrop containing *Ostrea multilirata* var. *duvali* and is equivalent to it. No oysters were found in this particular outcrop although the calcareous composition suggests its equivalency. The top of this has been selected to mark the upper limit of the Caldwell Knob member. There is no apparent break above this calcareous bed.

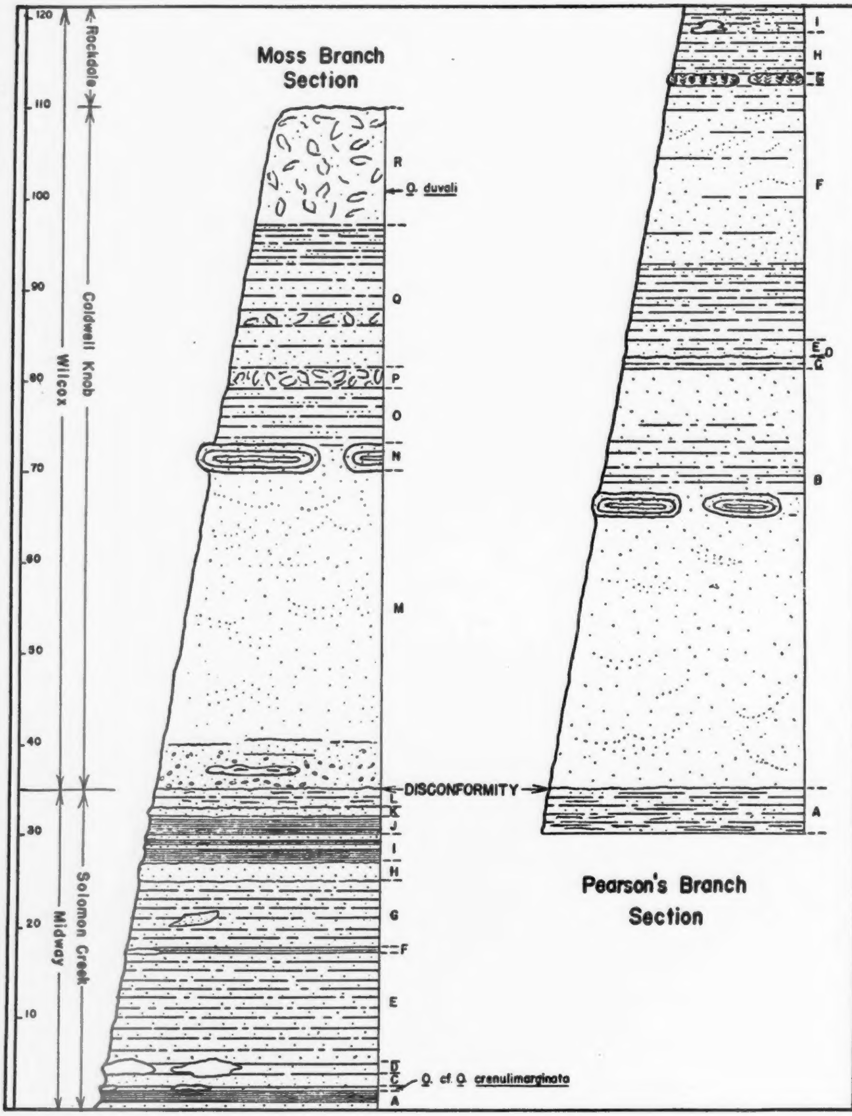

FIG. 3.—Moss Branch section and Pearson's Branch section.

MOSS BRANCH SECTION

This is the type locality of the Seguin formation. Although Plummer states that the type locality for the Caldwell Knob oyster bed is Caldwell Knob 10 miles north of Bastrop, it is believed that he was referring to the mounds of oysters near the headwaters of Moss Branch which are 10 miles northwest of Bastrop. The Caldwell Knob member as described by Plummer consists of a layer of oyster shells averaging a foot in thickness. The Caldwell Knob is redefined in this paper to include the beds lying between the disconformity at the base of the gray, massive sand (Bed M) and the top of the uppermost oyster reef (Bed R). The section here described includes the redefined Caldwell Knob member beds and the uppermost beds of the Solomon Creek member.

	Feet
Caldwell Knob member	
R. Oyster bed	13
Q. Silts and sands, covered near base, becoming clayey near top. Oyster reef in middle.	15.3
P. Oyster bed	2.3
O. Silt and clay, gray to yellow brown, thin-bedded, laminated	6.3
N. Sand ledge, brown, concretionary, dense, calcareous	3
M. Sand, gray, fine-grained, massive, cross-bedded. Base characterized by streaks and pebbles of clay	35
Disconformity	
Solomon Creek member	
L. Silty, sandy and finely laminated	1.5
K. Sand, fine yellow to gray	1
J. Clay and very fine laminated silt	2
I. Clay and sand alternating 6-18 inches	3
H. Sand, laminated and cross-bedded	2
G. Clays, laminated and very fine silty sand, 18-inch sand lens occurs within this interval	8
F. Sand, laminated and concretionary	.5
E. Silty sands, finely laminated, and clays	11
D. Calcareous concretionary layer of silty sand	1–2
C. Sand, soft, silty, gray	1–2
B. Fossiliferous concretion with *Ostrea* cf. *crenulimarginata*	.5
A. Sand, silty, laminated	1

The disconformity near the base of the section is identical with that at Smiley's Bluff. The beds below the disconformity show typical Solomon Creek lithologic character. Bed L consists of interbedded silts and clays which are characteristically laminated and cross-bedded. Spherical limonitic outlines represent decomposed marcasite concretions. The marcasite alters to melanterite, which upon oxidation becomes limonite.

Bed M consists chiefly of gray, cross-bedded sand. The base shows a conglomerate of clay pebbles and rippled stringers of clay which are distinctive features of this particular contact.

A brown concretionary ledge similar to that found in the Pearson's Branch section is exposed 35 feet above the disconformity. A reef of *Ostrea multilirata* var. *duvali* lies 6 feet above.

The top of the section is characterized by oyster reefs with interbeds of clays and sand. Bed R, which is the largest oyster reef, marks the top of the Caldwell Knob member. Shells of *Ostrea multilirata* var. *duvali* Gardner cover the ground

in countless hundreds as they weather out of their matrix of silts and clays. These reefs have been traced by Julia Gardner from the Brazos River in Milam County to the Rio Grande valley.

LITHOLOGIC COMPARISON OF SECTIONS

SOLOMON CREEK MEMBER

The clays and sands of the Solomon's Creek section are very similar to those of the Smiley's Bluff section. Both sections exhibit interbedded clays, silts, sands, and concretionary layers. The silt beds of both sections are characterized by cross-bedding, ripple-marks, and marcasite concretions, the clays by plant fragments. The sediments of these sections are commonly encrusted with limonite, copiapite, and gypsum.

There are many similarities between the ledge-forming concretions of the Solomon's Creek section, those of the Smiley's Bluff section, and the lower part of the Moss Branch section. Both consist of cross-bedded sand and silt cemented by calcite and exhibit brown-weathering fretted surfaces. The most important similarity is that the concretions at both sections contain a similar fauna. There is a general resemblance of shape and size of concretions at both sections.

The lithologic character and the sequences of deposition are remarkably similar. A faunal correlation leaves no doubt as to the general equivalency of Smiley's Bluff section with Solomon's Creek section. Matching of the section as shown in Figure 2 may vary somewhat from that indicated since the upper contact could not be located in the Solomon's Creek section, nor could the lower contact be exactly located in the Smiley's bluff section. However, the maximum possible error in matching should not be more than 20 feet. The alternative would be to match Bed C of the Smiley's Bluff section with Bed F of the Solomon's Creek section.

CALDWELL KNOB MEMBER

The lithologic characteristics of the Pearson's Branch and Moss Branch sections are identical. The disconformity marks the same lithological change at both exposures. The massive, gray sand bed at the base of the Caldwell Knob member is present in both sections. The presence of a brown concretionary ledge about 35 feet from the disconformity is a striking similarity.

The upper part of both sections indicates the presence of more than one oyster reef. Clays are more prominent in the upper part of both sections. A comparison of the sections with respect to the lithologic character and the relative thicknesses of beds shows that there were similar conditions of sedimentation at both places.

PALEONTOLOGY

COMPARISON OF SPECIES AND FAUNAS

The Solomon Creek member shows both a faunal and lithological facies change from the typical Wills Point formation. Although there are Wills Point fossils

that range up into the Solomon Creek, the Solomon Creek has many forms confined to it.

One of the largest fossils found in the Solomon Creek is *Hercoglossa*, which ranged as high as the thin oyster bed described in the Smiley's Bluff section. Microfossils are scarce and no typical Wilcox Foraminifera or ostracods were found in it.

The gastropods, although less numerous in individuals than the pelecypods, were useful in correlation and in the determination of faunal affinities. *Fusus quercollis*, described from the Midway of Alabama, is found in the Solomon Creek member at Smiley's Bluff and Solomon's Creek. This fossil does not occur in beds above the Midway of Alabama. The similarity between *Volutocorbis kerensensis* from the Wills Point and *Volutocorbis olssoni* Plummer from the Solomon's Creek section is striking. The principal difference is the lighter ribbing of the latter species.

Turritella polysticha, Turner and Stenzel, was found in the upper Wills Point beds on Solomon's Creek and ranges upward to the top of the Solomon Creek member. The range of this *Turritella* without a noticeable change probably indicates the absence of a time break of any great magnitude.

The most numerous species of gastropods found in the Solomon Creek member are *Pleurotoma ostrarupis* Harris, *Pseudoliva ostrarupis* var. *pauper* Harris, *Fusus ostrarupis* Harris, and *Levifusus* species. *Pleurotoma ostrarupis* was described by Harris from Smiley's Bluff. Harris states tht this species is common in material from Matthews' Landing, Alabama. *Pseudoliva ostrarupis* var. *pauper* and *Fusus ostrarupis* were figured by Harris from specimens found at Smiley's Bluff. These species have been noted from here and from Solomon's Creek. *Levifusus* species cf. *L. lithae* Gardner is similar to *Levifusus pagoda* Heilprin from Matthews' Landing. *Levifusus lithae* Gardner was described from the Wills Point formation of Texas.

The oyster found below the disconformity at Smiley's Bluff and at Moss Branch is similar to *Ostrea crenulimarginata*. *Ostrea crenulimarginata* is characteristic of the Clayton formation, lower Midway of Alabama.

The fauna of the Solomon Creek member shows more affinities with the Midway fauna than with the Wilcox. Species of the Midway range up into the Solomon Creek beds without any perceptible change. Others show only a slight change. A change in environmental conditions brought in different species, which are found only on the Solomon Creek member and are indicative of that particular horizon.

The Caldwell Knob member has few species. *Ostrea multilirata* var. *duvali* Gardner is abundant and is similar to *Ostrea arrosis* Aldrich, described from the basal Wilcox, Nanafalia formation, at Fleming's Mill, on Pea River, in southwest Alabama. *Ostrea multilirata* is reported to occur with *Ostrea thirsae* at the base of the Wilcox in Louisiana (Le Blanc and Barry, 1941, p. 735).

MECHANICAL ANALYSES

Samples of sands from the Solomon Creek member, bed T in the Solomon's Creek section and bed G in the Moss Branch section and samples from the Caldwell Knob member, bed M in the Moss Branch section 2–6 feet above the disconformity were screened and the physical characteristics of the sands determined and plotted by Foster Weldon, a graduate student in the department of geology at the Agricultural and Mechanical College of Texas. The cumulative curves and the constants are shown in Figure 4.

TABLE I

FAUNAL LIST

Name of Species	*Smiley's Bluff Solomon Creek Member*	*Solomon's Creek Solomon Creek Member*	*Other Localities*
Fusus quercollis Harris	x	x	Midway; 1 mile west of Oak Hill, Alabama
Pleurotoma ostrarupis Harris	x	x	Midway; Matthews' Landing, Alabama
Pseudoliva ostrarupis var. *pauper* Harris	x	x	
Pseudoliva ostrarupis Harris	x	x	
Fusus ostrarupis Harris	x	x	
Turritella polysticha Stenzel and Turner	x	x	Top of Wills Point of Solomon's Creek, Texas
Levifusus cf. L. *lithae* Gardner	x	x	*Levifusus lithae* ss. described from Wills Point formation, Maverick County, Texas
Levifusus species	x	x	
Cardium species	x	x	
Orthosurcula species	x	x	
Buccitriton species	x	x	
Nuculana protexta Conrad	x	x	Wilcox, Greggs Landing, Alabama
Ancilla mediavia Harris	x	x	Midway; Matthews' Landing, Alabama
Volutocorbis olssoni Plummer	x	x	Very similar to *V. kerensensis* Plummer from beds immediately underlying

The similarity in shape of the curves for the pair of samples above and the pair below the disconformity may be noted; likewise the difference in the size constants between the Solomon Creek and Caldwell Knob member samples.

CONCLUSIONS

Detailed sections of the Seguin formation show that in two areas separated by a distance of 65 miles the lithologic sequences are remarkably similar. In both areas a disconformity appears at approximately the same position in the section. Below the disconformity the beds in both areas contain the Solomon Creek fauna; above the disconformity are the beds containing *Ostrea multilirata* var. *duvali*. A study of the Solomon Creek beds and fauna shows that the changes are grada-

tional from the Wills Point formation below and that the faunal affinities lie with the Midway rather than the Wilcox.

The lithologic sequence above the disconformity begins with a cross-bedded sand locally containing a clay pebble conglomerate at the base. Upward the sequence changes to clays, silts, and beds of *O. multilirata* var. *duvali*. This oyster

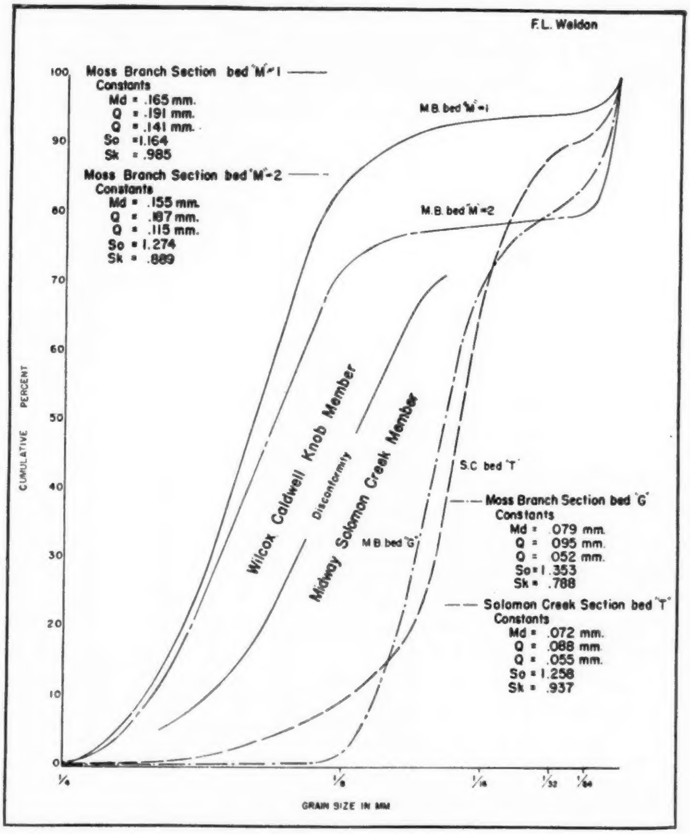

FIG. 4.—Cumulative curves of mechanical analyses and grain-size constants for samples from Caldwell Knob member and Solomon Creek member.

is found associated with *Ostrea thirsae* in the basal Wilcox of Louisiana and its analogue *O. arrosis* is found in the Nanafalia formation, basal Wilcox of Alabama. It appears therefore that the logical place to draw the line between the Wilcox and Midway in Texas is at the disconformity which separates the two faunas.

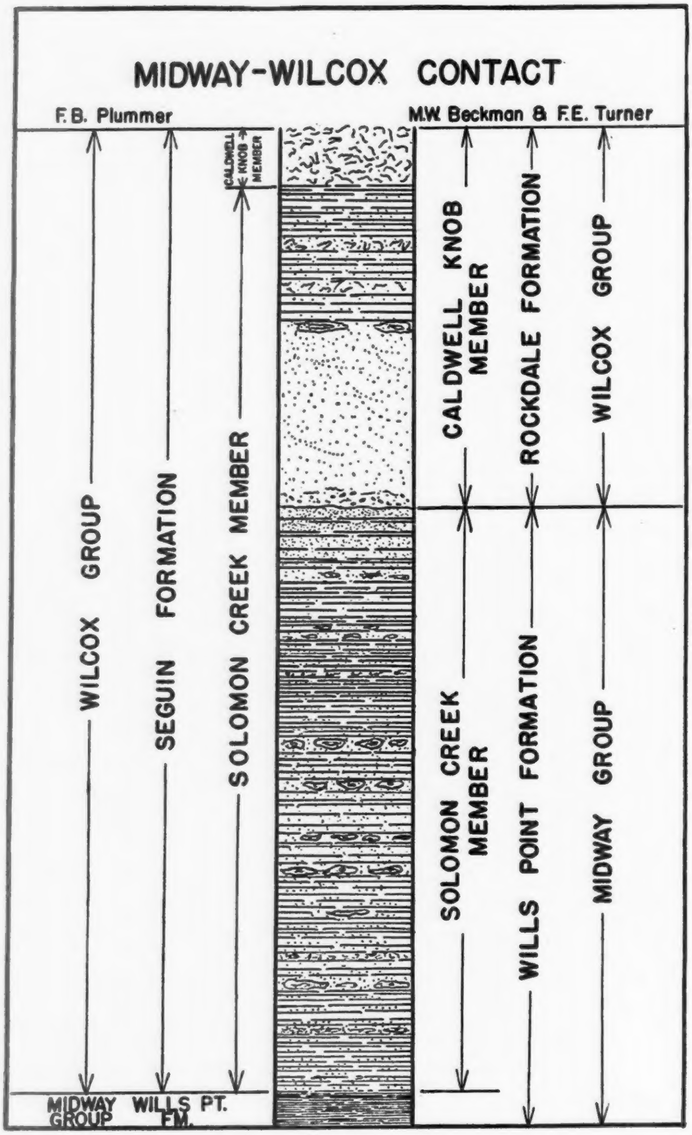

FIG. 5.—Comparison of section as given by Plummer with that proposed in this paper.

Mechanical analyses of the sands above and below the disconformity show noticeable differences in shape of the cumulative curves and in the grain-size constants. The sorting constants are nearly equal.

To avoid confusion in the stratigraphic units it seems desirable to redefine the members of the Seguin formation, limiting the Solomon Creek member to the beds below the disconformity and above the typical Wills Point clays. The Caldwell Knob member should be extended to include all the oyster beds and the sands below, down to the disconformity.

Where it is possible to recognize the divisions as redefined, the Solomon Creek member should be regarded as a member of the Wills Point formation and the Caldwell Knob beds as the basal member of the Rockdale formation. For mapping purposes where these divisions can not be differentiated it may be necessary to continue the use of the Seguin formation, recognizing that it contains the break between the Midway and Wilcox. Figure 5 shows the section as given by Plummer and the proposed changes by the writers.

The most significant conclusions from the economic standpoint to be drawn from the stratigraphy are that in the Solomon Creek and Caldwell Knob members of what has been known as the Seguin formation, the sediments and fauna indicate nearshore marine and lagoonal conditions along the line of the present outcrop. Downdip the section may be expected to be entirely marine.

In Milam County a well sorted sand, cemented with calcium carbonate and containing grains of weathered greensand, occurs 200 feet or more above the Caldwell Knob member, suggesting a thin marine lentil well up in the Rockdale. The presence of marine Tuscahoma and Bashi equivalents of the Wilcox along the Sabine River and marine upper Wilcox in Bexar County is well known. This known condition of alternating marine and non-marine wedges through the Wilcox and upper Midway on the surface suggests that downdip many more of these alternations may be expected and that there are many possibilities of the development of stratigraphic traps where well sorted marine sands wedge out updip between poorly sorted and relatively impervious non-marine facies, and that there are petroleum production possibilities anywhere in the section from the Wills Point clays of the Midway up to the top of the Wilcox.

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VOL. 27, NO. 5 (MAY, 1943), PP. 622-631, 5 FIGS.

ORIGIN OF SILICEOUS DOCKUM CONGLOMERATES[1]

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ABSTRACT

A fossiliferous chert shingle discovered in a Dockum outlier in Motley County, Texas, contained fusulinids which apparently came from the Hueco, Franklin, or Glass mountains of West Texas. A suite of Dockum pebbles was collected from this outlier and a megascopic and microscopic examination indicated a source near the Marathon uplift, a distance of at least 300 miles.

INTRODUCTION

In the fall of 1941 a fossiliferous chert shingle was discovered in a Dockum conglomerate outlier in the SE. $\frac{1}{4}$ of Sec. 127, John H. Gibson Survey, Motley County, Texas (Fig. 1). It was believed that by the identification of the fossils the source of the conglomerate could be determined. If this study were successful it was believed that a mineralogical examination of a representative suite of pebbles would shed additional light upon their province or geographic origin. The results appear to be in agreement.

Unfortunately the Dockum conglomerates are represented by two phases. One is a siliceous conglomerate dominant from Motley County southward; the other is a clay-ball conglomerate dominant from Motley County northward. No information was obtained relative to the source of the clay-ball conglomerate. No igneous pebbles were found *in situ*. Since the fusulinids in the chert shingle indicate its source, the name "rosetta stone" has been applied to it.

UPPER TRIASSIC OR DOCKUM SERIES

The "Dockum beds"[3] were first described by Cummins;[4] the type locality is at Dockum in Dickens County, Texas. Later an Upper Triassic age was assigned to them.[5] Still later work by Drake,[6] Cope,[7] and Gould[8] adequately described

[1] Manuscript received, September 12, 1942.

[2] Geologist, Humble Oil and Refining Company. The writer is indebted to G. E. Goodspeed of the University of Washington for all petrographic determinations; to J. W. Skinner, Humble Oil and Refining Company, Midland, Texas, for the identification of the fusulinids contained in the chert shingle; and to F. W. Rolshausen, Humble Oil and Refining Company, Houston, Texas, for the photographs. Permission to publish was granted by the Humble Oil and Refining Company of Houston, Texas.

[3] E. H. Sellards, W. S. Adkins and F. B. Plummer, "The Geology of Texas, Vol. 1, Stratigraphy," *Univ. Texas Bull. 3232* (1932), pp. 240–53.

[4] W. F. Cummins, "The Permian of Texas and Its Overlying Beds," *Texas Geol. Survey Ann. Rept. 1* (1890), p. 189.

[5] *Idem*, "Report on the Geology of Northwest Texas," *ibid., Ann. Rept. 2* (1891), pp. 424–31.

[6] N. F. Drake, "Stratigraphy of the Triassic Formation of Northwest Texas," *ibid., Ann. Rept. 3* (1892), pp. 227–47.

[7] E. D. Cope, "Report on the Paleontology of the Vertebrata-Triassic or Dockum Beds," *ibid.*, pp. 257–59.

[8] C. N. Gould, "The Geology and Water Resources of the Western Portion of the Panhandle of Texas," *U. S. Geol. Survey Water-Supply Paper* (1907), pp. 21–29.

the Upper Triassic stratigraphy and vertebrate paleontology of the Triassic in northwest Texas.

Due to the exotic nature of the pebbles constituting the Dockum[9] several theories have been advanced about the source of the material.[10] The problem is further complicated by the presence of two distinct types of conglomerates. One

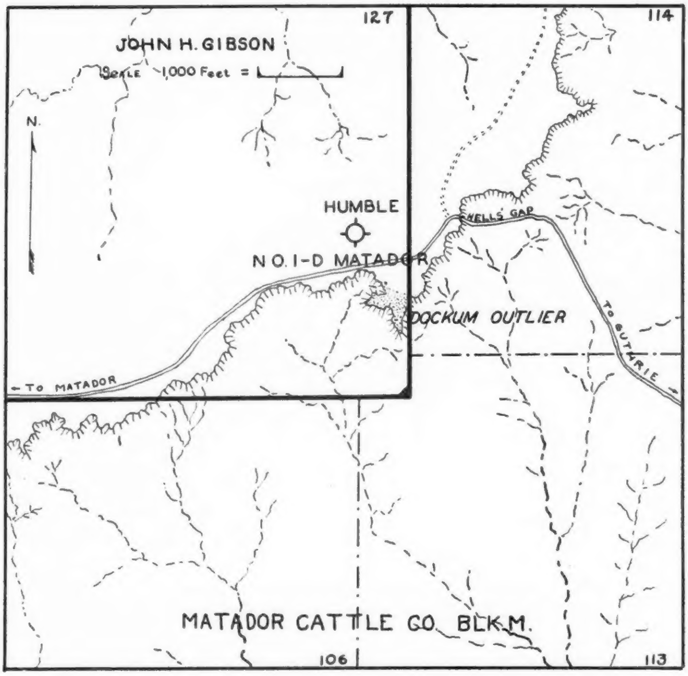

FIG. 1.—Geographic location of Dockum outlier.

is essentially siliceous with minor metamorphic types; the other, a clay-ball type, is essentially composed of earthy dolomite and limestone pebbles. Obviously each had a different source.

The outlier in which the "rosetta stone" was found is 8 miles east of the main Dockum escarpment. It is capped by weathered caliche of Recent age and lies on the Quartermaster of Upper Permian age (Fig. 3). Some igneous pebbles were noted lying on the caliche, but these are not present in the Dockum conglomerates.

[9] N. F. Drake, *op. cit.*, pp. 227–31.

[10] E. H. Sellards, W. S. Adkins, F. B. Plummer, *op. cit.*, p. 245.

Since nothing remains at the site of the old Dockum Ranch Post Office, and as its geographic position is shown on only old county maps, its exact location should be preserved in the literature (Fig. 2).

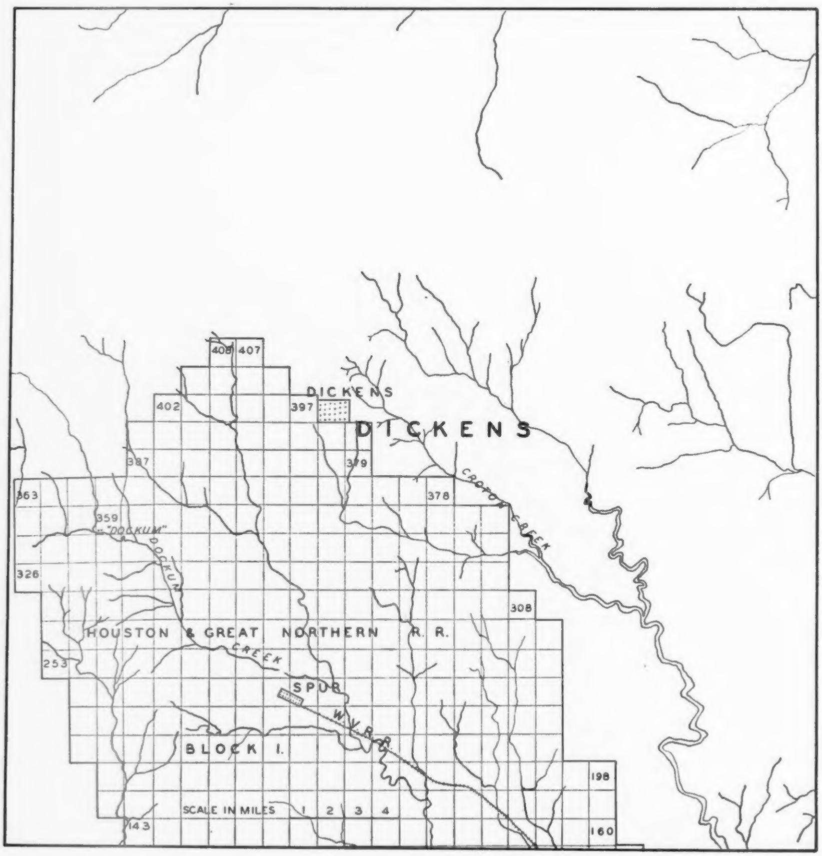

FIG. 2.—Geographic location of type Dockum, Dickens County, Texas.

PROPERTIES OF DOCKUM PEBBLES

CHALCEDONY[11]

More than 90 per cent of the pebbles constituting the Dockum conglomerates in Motley County, are composed of chalcedony represented by a variety of spe-

[11] A. J. Moses and C. L. Parsons, *Elements of Mineralogy, Crystallography and Blowpipe Analysis.* 5th ed., 2d printing (1920), p. 573. D. van Nostrand Company, New York.

cies. These species are differentiated by their color:[12] *chert*, white, gray, or other light colors; *flint*, smoky gray to nearly black; *jasper*, red, brown or yellow; *agate*,

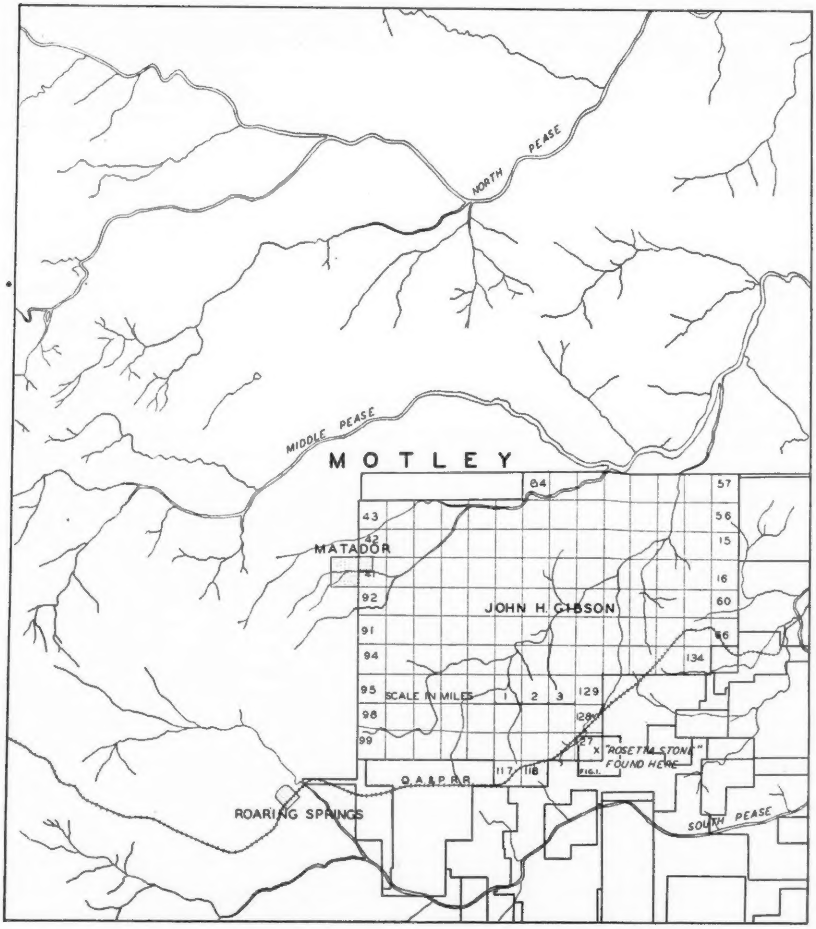

FIG. 3.—Geographic location of area where "rosetta stone" was discovered.

variegated colors in concentric bands. *Novaculite* may be represented, but in hand specimens it is impossible to differentiate it from some of the other species of chalcedony.

[12] W. H. Twenhofel, *Treatise of Sedimentation*. 2d ed. (1932), pp. 519–46. Williams and Wilkins Company, Baltimore.

CHERT

Inasmuch as the "rosetta stone" is included in this species it is described first (Fig. 4).

Size.—Length, 9.8 cm.; width, 5.0 cm.; thickness, 2.2 cm.

Color.—Reddish brown to ocher on weathered surface. Light gray on fresh surface.

Physical aspect.—Surface of "rosetta stone" is pitted because of removal of fusulinids or parts of them. Distinct bedding about 4 mm. thick is evident although it does not show well in photograph. Edges are moderately rounded, while fracturing with no apparent displacement has occurred at least twice.

Fossils.—The following have been identified; *Schwagerina franklinensis*[13] *S.* cf. *huecoensis*[14] *S.* sp. Preservation of fusulinids is extremely good.

Possible sources of derivation.—*S. franklinensis* has been reported in Hueco limestone in the Franklin Mountains and in the Wolfcamp of the Glass Mountains.[15] So far as known it is confined to the upper third of the Wolfcamp. *S. huecoensis*[16] has been reported in Hueco limestone of the Hueco, Franklin, and Sierra Diablo mountains; throughout the Wolfcamp of the Glass Mountains; and on the east side of the Permian basin where it has been found 20 feet above the Saddle Creek limestone 5 miles west of Fife in northwestern McCulloch County (Fig. 5).

OTHER CHERT PEBBLES

Size.—Maximum dimension observed, 8.7 cm.

Color.—Translucent, milky, white, pale green, glassy-green, ocher-green, pale tan, tan, ocher, gray-brown, rose-pink, ash-purple, light gray, and gray.

Physical aspect.—Due to peculiar nature of rock shattering all pebbles are angular to blocky, edges well rounded, commonly bounded on two sides by bedding planes. Angular solution pits are common, probably due to solution at point of contact between pebbles. Some are massive, showing no bedding, others are distinctly bedded, ranging from 0.5 mm. to one or more centimeters and ordinarily of different shades of color. Many contain spherules of softer material which upon weathering cause a pitted appearance. On fresh exposure, spherules do not appear very different from matrix. A few variegated pebbles consist of recemented angular breccia. Others contain blebs and veins of quartz, and some white varieties contain a moss of manganese, thus resembling moss agate. A few speckled with iron oxide contain pale green, elongate amorphous fragments that may have been volcanic ash. Upon fracturing it is noted that zones of weathering are much off center, due to shattering of the pebble during transportation and the resulting unequal weathering of fresh and old surface.

Fossils.—Sponge spicules are common and belong to *Monactinellida*.[17] Very small round objects may be radiolaria. One probably represents genus *Staurolonche*.[18]

Possible sources of derivation.—Practically unlimited, being both from sedimentary and metamorphic rocks. Field observations indicate, however, green varieties limited in dis-

[13] C. O. Dunbar and J. W. Skinner, "Permian Fusulinidae of Texas," *Univ. Texas Bull. 3701* (1937), p. 628.

[14] C. O. Dunbar and J. W. Skinner, *op. cit.*, p. 627.

[15] *Ibid.*, p. 630.

[16] *Ibid.*, p. 628.

[17] K. A. Von Zittel, *Text Book of Palaeontology*. 2d ed. (1927), pp. 50–51. The Macmillan Company, New York.

[18] *Ibid.*, p. 42.

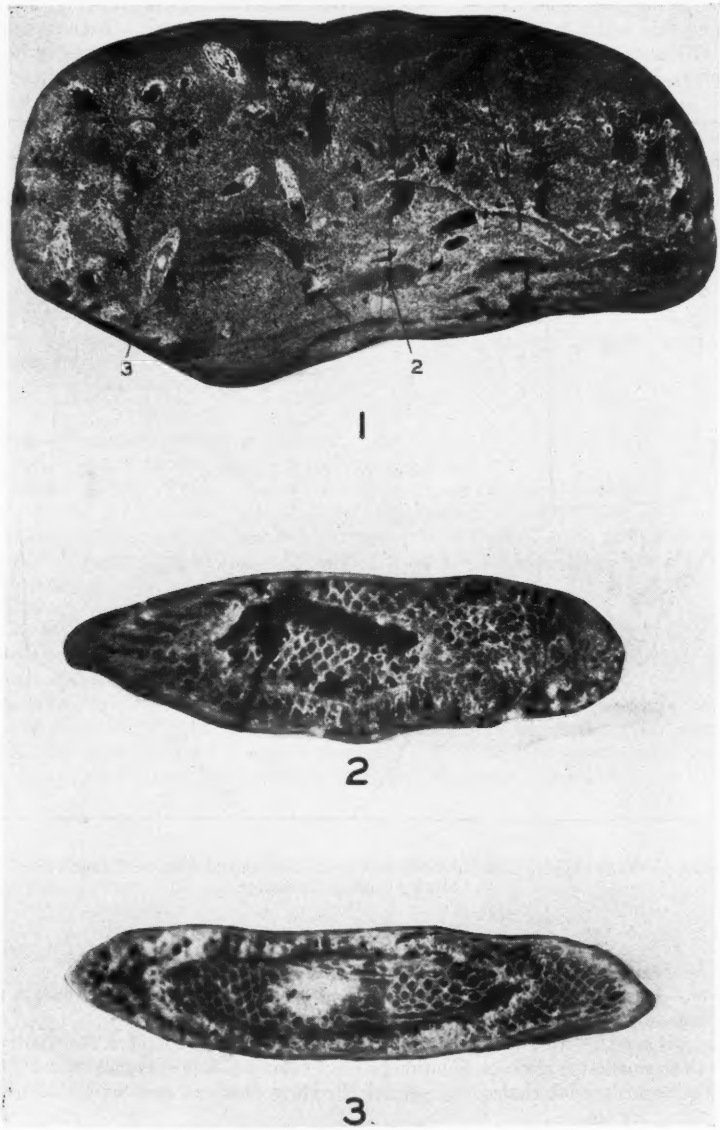

FIG. 4.—(1), "Rosetta stone." Natural size. (2), *Schwagerina huecoensis* ? 6×. (3), *Schwagerina franklinensis*. 6×.

tribution at outcrop. The Caballos[19] of Marathon and Solitario uplifts (Fig. 4), West Texas, contain many beds of green chert, and are radiolarian-bearing. Arkansas novaculite[20] of Ouachita Mountains in Arkansas and Oklahoma also contains many beds of green chert, but no radiolarians have been reported.

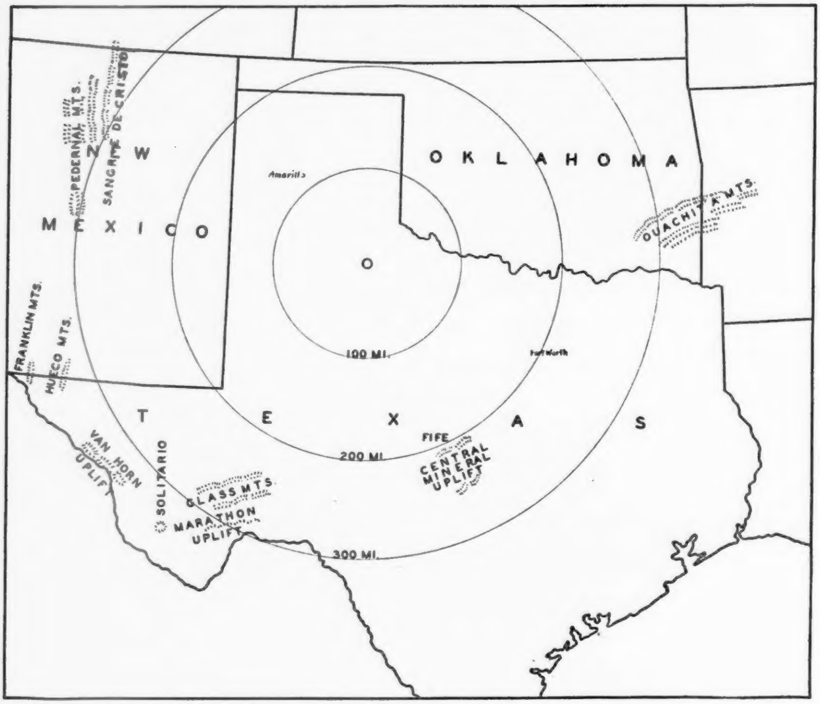

FIG. 5.—Regional map showing location of positive areas and relative distances from Motley County, Texas.

FLINTS

Size.—Maximum dimension observed, 7.5 cm.

Color.—Dark gray, gray-black, black, and brown. Some rare varieties contain translucent salmon-pink and opalescent spots.

Physical aspect.—All are angular to blocky with edges well rounded. Angularity persists even to smallest fragments. Solution pits not common. Some pebbles show evidences of fracturing with much chalcedony veining. Bedding common, maximum thickness observed being 2.5 cm.

[19] E. H. Sellards, W. S. Adkins, F. B. Plummer, *op. cit.*, pp. 87–88.

[20] Carey Croneis, "Geology of the Arkansas Paleozoic Area with Especial Reference to Oil and Gas Possibilities," *Arkansas Geol. Survey Bull. 3* (1930), pp. 104–09.

Fossils.—Sponge spicules common, all belonging to order *Monactinellida*. Radiolarians of suborder *Spumellaria*,[21] abundant. Average diameter, 64 microns. Some filled with opalescent chalcedony. All internal structure obscured.

Possible sources of derivation.—Pebbles containing radiolarians are lithologically similar to the Caballos, Arkansas novaculite, and Maravillas, but radiolarians have been reported only in Caballos.[22] Plummer[23] states:

> We have not observed any radiolaria in any of the flints or shales which I have studied in the Llano region [Bend and Marble Falls]. However, radiolaria have been discovered by members of the Bureau in some cherts from wells below the Cretaceous east of the Llano uplift [Central Mineral uplift]. . . . Also some radiolaria have been noticed in chert pebbles in Strawn [Pennsylvanian] conglomerates in the Mineral Wells district which are evidently derived from pre-Cretaceous rocks to the east.

Brackets are the writer's.

It seems from Plummer's comments that flints bearing radiolaria are present east of Central Mineral uplift, and it is probable that Arkansas novaculite may contain radiolaria, but they have not been reported.

JASPER

Size.—Maximum dimension observed, 5 cm.

Color.—Yellow, brown, light red, red, blood-red, and maroon.

Physical aspect.—Highly irregular in outline. Much apparently occurred as vein material and some is cut by white quartz. Some is spherulitic, spherules being either harder or softer than matrix, causing surface to be strongly pitted. Oölitic jasper, rare. Many pebbles are a mass of angular fragments, probably breccia recemented with silica. A few show traces of stratification.

Fossils.—None observed.

Possible sources of derivation.—Pebbles do not appear to have been derived from any of above beds but came from some area which had undergone extensive metamorphism[24] and metasomatism.[25]

Sangre de Cristo Mountains of New Mexico cover an area large enough to be source of supply. However, as their uplift has tilted adjacent Dockum beds, it does not seem probable that this is source area.[26] Pedernal Mountains[27] also may have been source, but area is small. Most probable source is land mass south and southwest of Marathon and Van Horn uplifts.

AGATE

Only one pebble noted. It has very irregular outline. Greatest dimension, 2 cm. Coloring, brilliant. Source, probably same as that for jasper.

QUARTZ

Size.—Maximum dimension observed, 7.5 cm.

[21] K. A. Von Zittel, *op. cit.*, p. 42.

[22] E. H. Sellards, W. S. Adkins, F. B. Plummer, *op. cit.*, pp. 78–80.

[23] F. B. Plummer, letter of January, 1942.

[24] A. Harker, *Petrology for Students*. 6th ed. (1923), pp. 263–96. Cambridge University Press, London.

[25] *Ibid.*, pp. 246–51.

[26] N. H. Darton, " 'Red Beds' and Associated Formations in New Mexico," *U.S. Geol. Survey Bull. 794* (1928), pp. 272–74.

[27] *Ibid.*, pp. 283–84.

Color.—Translucent, white, pale pink, salmon-pink, tan, dark green, and smoky.

Physical aspect.—Ordinarily well rounded, but many pieces are more or less flat in one plane. Pebbles derived from massive quartz, well rounded. Those derived from veins up to 6 cm. thick commonly flat in a plane at right angles to vein. This characteristic results from fracturing paralleling direction of growth of individual quartz crystals from walls of vein. Fracturing shows vugs and drusy cavities with some altered ferro-magnesian minerals.

Fossils.—None.

Possible sources of derivation.—All pieces derived apparently from large and small quartz veins, possibly some pegmatites. Ouachita Mountains of Oklahoma and Arkansas. Central Mineral, Marathon, and Van Horn uplifts, and Pedernal Mountains may all have been source areas, but area south and southwest of Marathon uplift is the most probable.

QUARTZITE

Size.—Maximum dimension observed, 12.5 cm.

Color.—White, light buff, tan, green, reddish brown, dark gray-brown, and black.

Physical aspect.—All pieces well rounded to egg-shaped as if source material were massive; some pieces finger-like as if source were thin-bedded. Where observable, sand grains are well rounded; the possibility of their being frosted is masked by secondary enlargement. Some were probably greywacke as they contain masses of hematite and kaolin; others contain so much ilmanite that they are very dark gray. Latter variety is ordinarily pitted and has reddish-brown cast due to alteration of iron compounds. Others are fractured and veined with quartz. One tabular form is fine dense reddish-brown well bedded grit. Some have been so altered that they are now pure granular quartz.

Fossils.—None.

Possible sources of derivation.—All these pebbles came from highly metamorphosed landmass. Such an area of sufficient size may be found only south of Marathon uplift, or any other place south and east of Marathon–Ouachita belt.

QUARTZITIC CONGLOMERATE

Size.—Maximum dimension observed, 12.5 cm.

Color.—Milky, white, light gray, and salmon-pink.

Physical aspect.—Well rounded to egg-shaped. Many constituting quartzitic conglomerate contain well rounded clear quartz in matrix of silica. Some have pale blue cast probably due to strain; others are mylonized. Some are darkened by abundance of ilmanite and magnetite; others have been stained with iron oxide due to weathering of included ferro-magnesian minerals. Much sericite and some chloritic material. Some brownish black mica, probably biotite, was noted. Sheaves, clusters, and plumes of pale pink sillimanite very abundant. A few typical examples of puddingstone.

Fossils.—None.

Possible sources of derivation.—Same as for quartzite.

QUARTZ SCHIST

Thin sections were made of some of this material. Comments by G. E. Goodspeed[28] follow.

Megascopic.—A fine grained slightly schistose rock composed chiefly of quartz with a few grains of magnetite and small (2 mm.) bunches of a white fibrous mineral parallel to the schistosity. Microscopic. Interlocking grains of quartz ($\frac{1}{2}$ mm. or less in size) with sutured boundaries. Scattered grains of magnetite and plumose tufts (approx. 2 mm.) of a fibrous mineral of relatively high index (Ng

[28] G. E. Goodspeed, letter of June, 1942.

approx. 1.67) positive elongation (length slow) parallel extinction, rather strong birefringence and a square-like cross section. Anthophylite and sillimanite may have properties similar to the above, but the square cross section indicates sillimanite. Rock is a quartz schist.

Possible sources of derivation.—Same as for quartzite.

MICA SCHIST

Size.—Maximum dimension observed, 10.0 cm.

Color.—Tan, tan-buff, ocher, pink, orange-red, dark purple, light and dark gray.

Physical aspect.—Very noticeable as they look like pieces of horn on the ground. All are flattened and elongate parallel with schistosity. Some have been cut with quartz veins and all tend to fracture into elongate slivers.

Fossils.—None.

Possible sources of derivation.—Severely metamorphosed area the same as for quartzite.

HORNFELS

Size.—Maximum dimension observed, less than 5.0 cm.

Color.—Ocher, very dark maroon-brown, dark gray, gray-black, and black.

Physical aspect.—All elongate parallel with bedding (?). Some contain pseudomorphs of hematite after pyrite. In one, remains of cone-in-cone structure clearly discernible. All have conchoidal fracture and are intensely veined with quartz.

Fossils.—None.

Possible sources of derivation.—Metamorphosed shales and slates may be found in all areas mentioned under quartz.

CONCLUSIONS

From the foregoing evidence it is believed that those conglomerates of the siliceous type were derived from an area south and southwest of the Glass Mountains. This substantiates the evidence of the "rosetta stone."

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GEOLOGICAL NOTES

UPPER DESMOINESIAN AND LOWER MISSOURIAN ROCKS IN NORTHEASTERN OKLAHOMA AND SOUTHEASTERN KANSAS[1]

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Norman, Oklahoma, and Lawrence, Kansas

The purpose of this paper is to summarize the known stratigraphic relations of the younger Desmoinesian and older Missourian rocks in northeastern Oklahoma and southeastern Kansas. Because of the overlap from the south of strata of Missourian age on those of Desmoinesian age and because of facies changes especially pronounced in the Missourian rocks, correlation in this area has been difficult. The thickness of the stratigraphic section discussed is about 300 feet. The rocks are chiefly clastic.

Four major divisions of Pennsylvanian rocks separated by regional unconformities have been generally recognized as occurring in Oklahoma. These divisions are commonly classified as series, and listed in upward order they are: (1) Morrowan, (2) Desmoinesian, (3) Missourian, and (4) Virgilian series. Rocks of the Morrowan and of the lower part of the Desmoinesian series are not known to be present in Kansas. Rocks herein discussed lie in the upper part of the Desmoinesian and lower part of the Missourian series. Figure 1 represents graphically outcrops of these rocks that are situated in Kansas and Oklahoma along a line passing through Coffeyville, Kansas, and extending about 30 miles into each state. The deposits are particularly interesting from stratigraphic and paleontologic standpoints because of the unconformity that they embrace and because of changes in facies that they reveal.

The rocks are not described in detail in this paper; the literature concerning them is not reviewed here, nor is mention made of many persons who have contributed to the knowledge of the geology of southeastern Kansas and northeastern Oklahoma. Detailed descriptions may be found by consulting the references listed at the end of the report.

ROCKS OF DESMOINESIAN AGE

Lenapah limestone.—The Lenapah limestone is the lowest stratigraphic unit that is discussed in this paper. It is the uppermost limestone formation in the Marmaton group (Moore, 1936, pp. 57, 66; Jewett, 1941). The correlation of the Lenapah from exposure to exposure within the parts of Oklahoma and Kansas covered by Figure 1 is well established and it is regarded as a lower key bed

[1] Presented before the Association at Denver, April 23, 1942. Manuscript received, October 5, 1942. Published with the permission of the director of the Oklahoma Geological Survey and the director of the State Geological Survey of Kansas.

[2] Field geologist, Oklahoma Geological Survey.

[3] Geologist, State Geological Survey of Kansas.

extending across an area that offers difficulties in stratigraphy. The Winterset limestone, which is the uppermost member of the formation called Dennis limestone in Kansas and Hogshooter limestone in Oklahoma, is likewise an important, trustworthy key bed and is represented graphically in Figure 1. The Winterset is the lowest limestone of Missourian age that persists with only minor facies changes across this area.

According to observations by Oakes, the unconformity that separates Desmoinesian from Missourian rocks in the northeastern Oklahoma region follows the eroded top of the Lenapah limestone. On the other hand, Jewett finds that nearly everywhere along the outcrop in Kansas a few feet of Desmoinesian shale is present above the Lenapah limestone.

Memorial shale.—In the vicinity of Tulsa, Oklahoma, the unconformity that separates Desmoinesian sediments from the Missourian lies some distance above the Lenapah limestone. Dott (1941) has applied the name, Memorial shale, to the beds between the Lenapah and the Desmoinesian-Missourian unconformity. The term Memorial is now used in Oklahoma and Kansas for all Desmoinesian rocks above the Lenapah limestone. As just stated Oakes has found evidence that the Memorial shale is absent in much of the part of Oklahoma in which the outcrops pictured in Figure 1 are situated. In Labette County, Kansas, characteristic Desmoinesian fossils, particularly the brachiopod, ***Mesolobus***, range several feet above the Lenapah limestone,—almost up to the base of the Hepler sandstone. Farther north, the shale occupying the interval between the top of the Lenapah limestone and the Hepler sandstone is seemingly unfossiliferous. This shale is considered to be separated from the Hepler sandstone by a disconformity and to rest conformably on the Lenapah limestone. It seems to be continuous with fossiliferous shale above the Lenapah in central Labette County, where Desmoinesian shells have been collected. Accordingly, it is held that this shale in Kansas is correlated properly with the Memorial shale in Tulsa County, Oklahoma.

ROCKS OF MISSOURIAN AGE

Seminole formation.—The type locality of the Seminole formation is in the southeastern part of Seminole County, Oklahoma, where strata assigned to this stratigraphic division rest unconformably on the Holdenville formation and are conformably overlaid by the DeNay limestone member of the Francis formation. Only within the last decade has the unconformity at the base of the Seminole rocks been recognized in northeastern Oklahoma and in southeastern Kansas (Moore, 1936, pp. 52, 53, 70, 71; Moore and others, 1937, pp. 39–43; Jewett, 1940, pp. 8–9). Its importance in northeastern Oklahoma was recognized by Robert H. Dott and Ronald J. Cullen while engaged in a research project of the Tulsa Stratigraphic Society, 1933. This disconformity separates the Desmoinesian rocks from overlying Missourian strata.

In the southern part of Tulsa County, Oklahoma, the pre-Missourian unconformity occupies a position 100 feet or more above the Lenapah limestone.

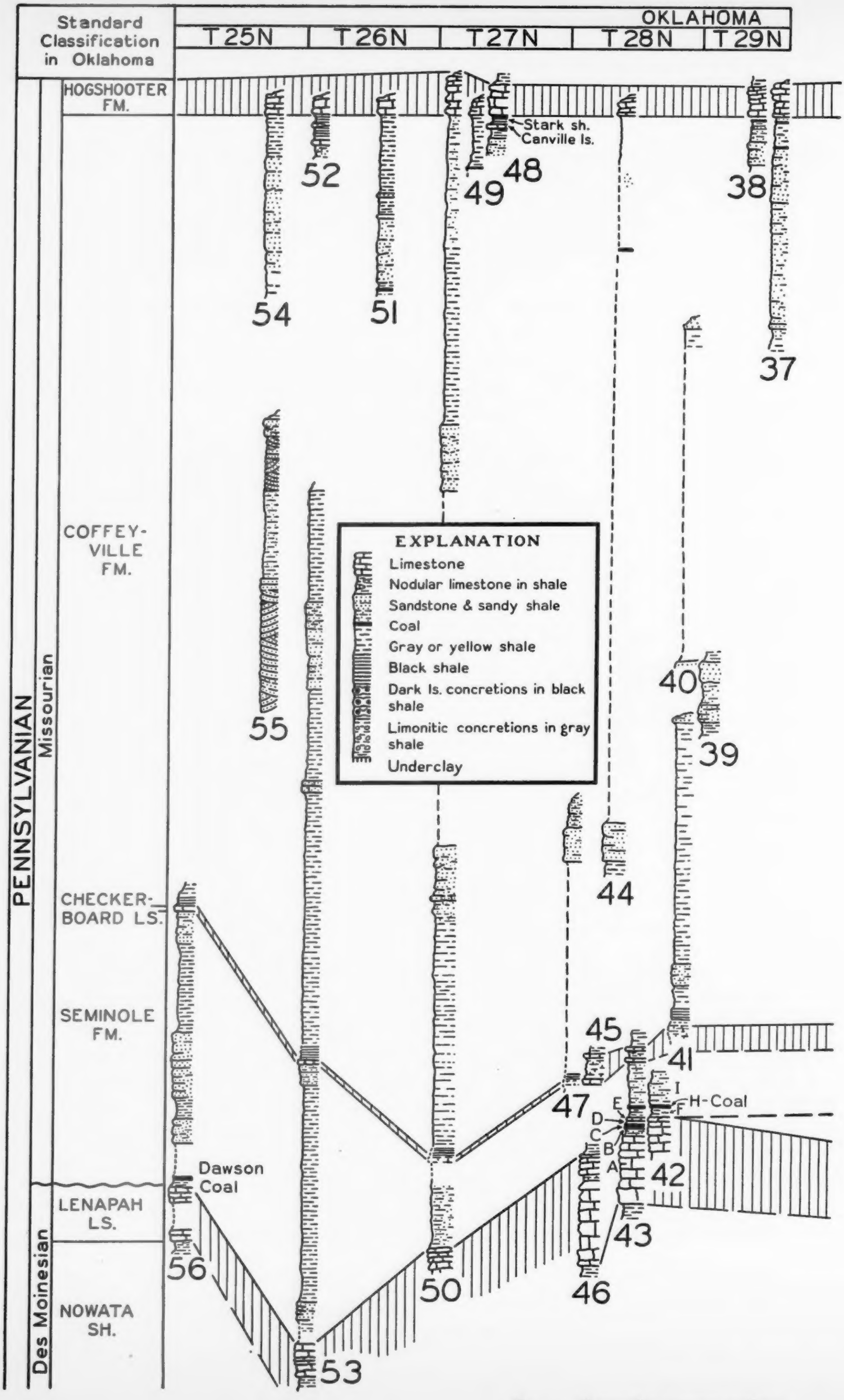
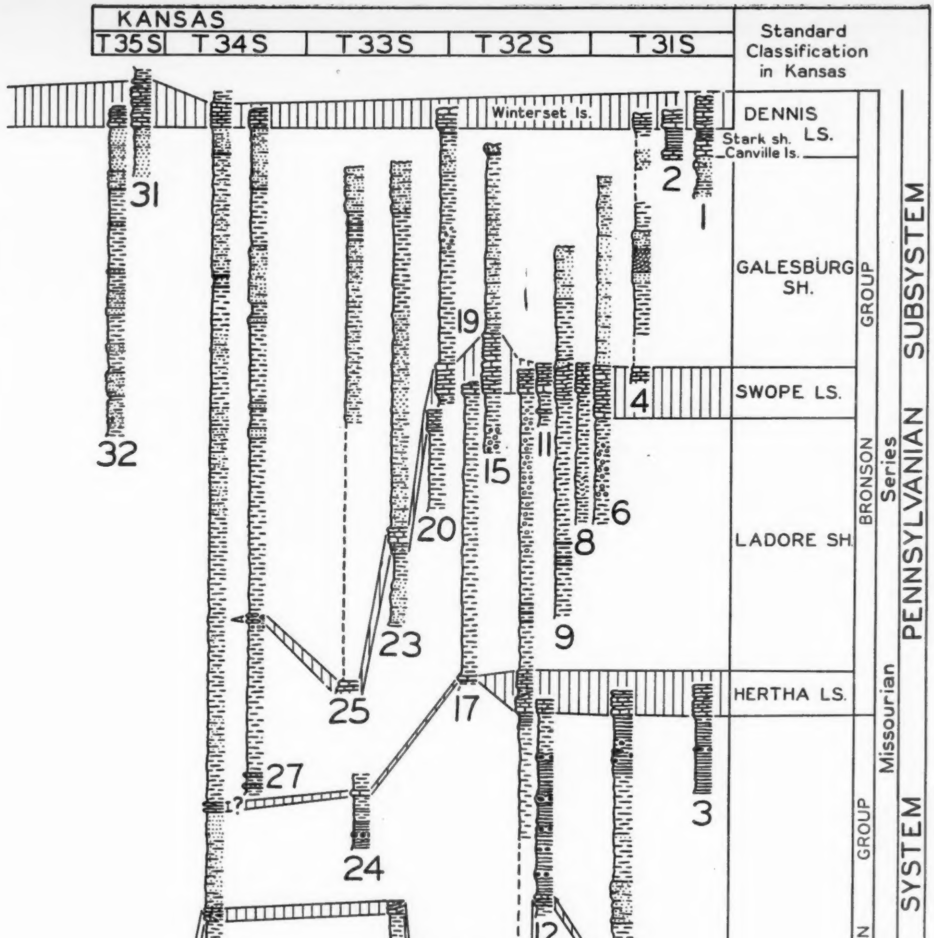


FIG. 1.—Composite outcrop sections,



northeastern Oklahoma and southeastern Kansas.

TABLE I

LOCATIONS OF OUTCROPS REPRESENTED IN FIGURE[1]

OUTCROPS IN KANSAS

Section No.	*Remarks*
1	Vicinity of NW cor., Sec. 16, T. 31 S., R. 18 E., Labette County.
2	A point south of center of E. line, Sec. 20, T. 31 S., R. 18 E., Labette County. Canville limestone and Stark shale members of Dennis formation are present many miles northward from this point.
3	Near Parsons County Club, in vicinity of NE. cor., Sec. 21, T. 31 S., R. 19 E., Labette County. Type exposure of Hertha limestone is about 14 miles N.-NE.
4	NW. ¼ Sec. 29, T. 31 W., R. 18 E., Labette County.
5	Along N. side of NE. ¼ Sec. 27, T. 31 S., R. 18 E., Labette County.
6	Along N. side of NW. ¼ Sec. 32, T. 31 S., R. 18 E., Labette County.
7	About center of E. line of Sec. 27, T. 31 S., R. 19 E., Labette County.
8	Near center of S. line of Sec. 5, T. 32 S., R. 18 E., Labette County.
9	In vicinity of SW. cor., Sec. 1, T. 32 S., R. 18 E., Labette County.
10	In SW. ¼, SW. ¼ Sec. 2, T. 32 S., R. 19 E., Labette County. This is type exposure of Idenbro limestone, upper member of Lenapah formation.
11	SW. cor., Sec. 10, T. 32 S., R. 18 E., Labette County.
12	Along W. side of NW. ¼, NW. ¼ Sec. 17, T. 32 S., R. 19 E., Labette County. Here is seen black platy shale with dark limestone concretions that is characteristic of Bourbon shale in southern Kansas.
13	Continuous section in S. ½ Sec. 7 and in the SE. ¼ Sec. 18, T. 32 S., R. 19 E., Labette County. Hertha limestone crops out at about center of S. line of Sec. 7.
14	About center of W. line of Sec. 20, T. 32 S., R. 19 E., Labette County.
15	Vicinity of NW. cor., Sec. 24, T. 32 S., R. 19 E., Labette County.
16	About center of Sec. 26, T. 32 S., R. 18 E., Labette County.
17	Along S. side of SE. ¼, SE. ¼ Sec. 27 and S. side of SW. ¼, SW. ¼ Sec. 26, T. 32 S., R. 18 E., Labette County.
18	SE. ¼ Sec. 35, T. 32 S., R. 19 E., Labette County. Hepler sandstone is exposed in old brick plant shale pit near center of section. *Mesolobus* and *Trachypora* occur in upper part of Memorial shale here.
19	Along S. side of SW. ¼ Sec. 31, T. 32, R. 18 E., Labette County.
20	About center of N. line of Sec. 6, T. 33 S., R. 18 E., Labette County.
21	Near west end of bridge over Pumpkin Creek at about center of S. line of Sec. 2, T. 33 S., R. 18 E., Labette County. *Mesolobus* occurs at top of Memorial shale here. *Trachypora* occurs in lower ½ of part exposed.
22	North of highway bridge over Pumpkin Creek in NW. ¼ Sec. 11, T. 33 S., R. 18 E., Labette County. *Mesolobus* occurs here in Memorial shale just below coal bed at base of Hepler sandstone.
23	About center of W. line of Sec. 15, T. 33 S., R. 17 E., Montgomery County, Kansas.
24	In SE. ¼ Sec. 19, T. 33 S., R. 18 E., Labette County.
25	About center of SW. ¼ Sec. 20, T. 33 S., R. 17, Montgomery County.
26	Near NW. cor., Sec. 33, T. 33 S., R. 18 E., Labette County.
27	Near center of NW. ¼ Sec. 14, T. 34 S., R. 17 E., Montgomery County.
28	About center of NW. ¼ Sec. 23, T. 34 S., R. 16 E., Montgomery County.
29	Shale pits in NW. ¼ Sec. 26, T. 34 S., R. 16 E., Montgomery County.
30	Immediate vicinity of SE. cor., Sec. 34, T. 34 S., R. 17 E., Montgomery County.
31	Along road along W. side of Sec. 2, T. 35 S., R. 16 E., Montgomery County.
32	Along S. side of SW. ¼ Sec. 3, T. 36 S., R. 16 E., Montgomery County.
33	About center of E. line of Sec. 11, T. 35 S., R. 17 E., Labette County.
34	West bank of Verdigris River at SE. edge of Coffeyville in Sec. 12, T. 35 S., R. 16 E., Montgomery County.
35	Near bridge over Verdigris River near center of S. line of Sec. 7, T. 35 S., R. 17 E., Montgomery County.
36	In barrow pit E. of U. S. Highway No. 169, 100 feet north of Kansas-Oklahoma line, north edge of South Coffeyville, Oklahoma, near SW. cor. of Sec. 13, T. 35 S., R. 17 E., Kansas.

[1] Sections Nos. 1–29 and 31–35 inclusive taken from the files of the Kansas Geological Survey. All others taken from the Oklahoma Geological Survey files.

OUTCROPS IN OKLAHOMA

Section No.	*Remarks*
37	Vicinity of E. ¼ cor. of Sec. 14, T. 29 N., R. 15 E., Oklahoma.
38	Vicinity of SW. cor. of Sec. 21, T. 29 N., R. 15 E., Oklahoma.
39	Vicinity W. ¼ cor. of Sec. 36, T. 29 N., R. 15 E., Oklahoma.
40	Along W. side of NW. ¼ Sec. 12, T. 28 N., R. 15 E.
41	Near E. ¼ cor. of Sec. 6, T. 28 N., R. 16 E., from black shale in draw west of highway to sandstone at top of ridge at west.
42, 43	Contiguous sections. No. 43 crops out along stream from point about ¼ mile W. of SE. cor. of Sec. 18, T. 28 N., R. 16 E., NW. to point near center of same section. No. 42 crops out in drainage ditch on E. side of U. S. Highway No. 169 immediately north of bridge over stream just mentioned. Outcrop of massive limestone A of both sections is continuous.
44	Measured across Secs. 20, 21, and 22, T. 28 N., R. 15 E.
45	About center of SE. ¼, NW. ¼ Sec. 25, T. 28 N., R. 15 E., west of Bell's Spurr, on U. S. 169, N. of Nowata, Oklahoma.
46	In quarry E. of U. S. Highway No. 169, NW. ¼, SE. ¼ Sec. 30, T. 28 N., R. 17 E., short distance SE. of Bell's Spurr.
47	Eastward ⅛ mile from SW. cor., Sec. 31, T. 28 N., R. 16 E. Checkerboard limestone does not crop out along road, but its horizon can be estimated within a few feet.
48	NW. ¼, NW. ¼ Sec. 18, T. 27 N., R. 15 E.
49	About center of NW. ¼ Sec. 30, T. 27 N., R. 15 E.
50	Across N. side of Secs. 3, 4, and 5, T. 26 N., R. 15 E.
51	Vicinity of NW. cor. of Sec. 15, T. 26 N., R. 14 E.
52	About ⅛ mile S. of center of Sec. 31, T. 26 N., R. 14 E.
53	Along south side of Secs. 32, 33, 34, and 35, T. 26 N., R. 15 E.
54	From E. ¼ cor. of Sec. 13, N. to ⅛ mile N. of SE. cor. of Sec. 12, T. 25 N., R. 13 E.
55	In SW. ¼, SW. ¼ Sec. 10, T. 25 N., R. 14 E.
56	Begins at base of Lenapah limestone, NE. cor. of Sec. 27, T. 25 N., R. 15 E., thence west along road to NW. cor. of Sec. 28, thence N. ¼ mile to base of upper sandstone. This upper sandstone and Checkerboard limestone were measured in draw ⅛ mile S. of N. ¼ cor. of Sec. 25, T. 25 N., R. 14 E.

In several of the Oklahoma sections the Checkerboard limestone does not actually crop out along the line of the sections but its position could be closely approximated from near-by observations.

However, farther north in Oklahoma, as indicated by exposures distributed from the middle part of T. 20 N., to the southern part of T. 25 N., the Lenapah limestone has been removed by pre-Missourian erosion except in a very few places.

The type exposure of the DeNay limestone is in Sec. 5, T. 4 N., R. 7 E., Pontotoc County, Oklahoma. It has not been traced into northeastern Oklahoma, but the Checkerboard limestone is tentatively correlated with the DeNay limestone (Oakes, 1940, 2d ref., p. 33), and the lower surface of the Checkerboard is regarded as the upper limit of the Seminole formation in northeastern Oklahoma and southeastern Kansas. The Checkerboard limestone is now recognized in southeastern Kansas (Fig. 1).

In Tulsa County and northward to the southern part of T. 25 N., Oklahoma, the Seminole formation includes three members. The lower member consists of sandstone and sandy, silty shale. The middle member consists predominantly of shale and includes the Dawson coal. The upper member, like the lower, includes sandstone and sandy, silty shale and extends northward into Kansas where it is inferred to be represented by the Hepler sandstone and overlying shale beds below the Checkerboard limestone. Immediately south of the area in which the exposures represented in Figure 1 are situated, the lower member of the Seminole is overlapped by the middle member.

At three places in Oklahoma, as shown in sections Nos. 42, 43, and 56 (Fig. 1)

a thin coal streak is known to occur a few feet above the Lenapah limestone. Fossils that are diagnostic of the Desmoinesian rocks have been found in the Lenapah limestone but not in the shale between the limestone and the coal.

Sections Nos. 42 and 43 show contiguous measurements of the Lenapah limestone and overlying Seminole rocks. These sections, as interpreted by Oakes, exhibit the pre-Missourian unconformity. The exposure represented by No. 43 crops out along a stream above and below U. S. Highway 169 northwestward from a point about $\frac{1}{4}$ mile west of the SE. corner of Sec. 18, T. 28 N., R. 16 E., to a point near the center of the same Section. No. 42 represents an exposure in the drainage ditch on the east side of U. S. Highway 169 immediately north of the bridge over the steam just mentioned. The outcrop of the massive part of the Lenapah limestone (A) of both sections is continuous. Shale divisions (B, C, D), as well as the thin upper limestone (E) of section No. 43, are present only locally in northeastern Oklahoma, and are absent in the exposure represented as No. 42. Geologists of the Oklahoma Survey at present regard these rocks as remnants of the upper part of the Lenapah limestone preserved from pre-Missourian erosion. The unconformity at the base of Missourian strata is accordingly drawn at the base of shale (F), and the coal in both sections is thought by Oakes to be the Dawson coal. Sandy shale (I) above the coal is classified as the upper sandy member of the Seminole formation.

Sections Nos. 30 and 36 are from the files of the Oklahoma Geological Survey. All other Kansas sections shown in Figure 1 are from records of the Kansas Geological Survey. In No. 30 the unconformity at the base of the Missourian series is drawn a few feet above the top of the Lenapah limestone, at the contact between dark clay shale, below, and sandy shale, above. At this place the Seminole formation is about 15 feet thick and in its upper part it contains sandstone that has characteristics of the Hepler sandstone. Farther north the Hepler sandstone lies on an uneven, locally channeled surface that marks the boundary between the Desmoinesian and the Missourian rocks (Jewett, 1940, pp. 8–9, 1941, Pl. 1).

The brachiopod, *Mesolobus*, characteristic of Desmoinesian rocks, has been found in the Memorial shale within a few inches of the base of the Hepler sandstone at the outcrops represented as sections Nos. 18, 21, and 22 (Fig. 1). Therefore, the lower coal shown in section 22 is of Desmoinesian age and is not the Dawson coal. Jewett believes that the coal represented in section No. 26 is also of Desmoinesian age and is probably the same as the lower coal bed shown in section No. 22.

A coal corresponding with the one above the Hepler sandstone occurs in Oklahoma, but it does not crop out in the places where the sections represented in Figure 1 were studied.

Checkerboard limestone.—The Checkerboard limestone is tentatively correlated with the DeNay limestone of east-central Oklahoma. There has been much conjecture as to the Kansas equivalent of the Checkerboard, but mapping and measuring of exposures by the writers have shown that it lies a few feet above the

Hepler sandstone and is not the Hertha limestone as some geologists have conjectured.

The Checkerboard limestone has not been traced northward beyond the northern part of Labette County, Kansas, and it is known not to be continuous over a wide area in southeastern Kansas and in western Missouri. One or more thin limestones are locally found a few feet above the Hepler sandstone north of Labette County, however. The Hepler sandstone has been traced by Jewett across southeastern Kansas into Bates and Cass counties, Missouri.

Coffeyville formation.—The history of Coffeyville as a stratigraphic name is somewhat involved but as now used by the Oklahoma Geological Survey, it applies to all rocks between the top of the Checkerboard limestone, below, and the base of the Hogshooter formation, above. In northeastern Oklahoma and in southeastern Kansas the Coffeyville formation consists chiefly of clay shale, silty and sandy shale, and sandstone. It is chiefly non-marine in origin.

Because of the discontinuity of the Checkerboard limestone northward and of the Hertha and Swope limestones southward, the terms Seminole and Coffeyville can not be usefully applied as stratigraphic names in Kansas except in a small area in the southern part of the state (Jewett, 1937, p. 35). The Bourbon formation, very well defined in Kansas, is equivalent to the upper part of the Seminole formation and the lower part of the Coffeyville formation. The Hertha limestone, Ladore shale, Swope limestone, and Galesburg shale, all of which are readily traced from southern Kansas to southern Iowa, comprise northward equivalents of the upper part of the Coffeyville rocks.

Dennis or Hogshooter formation.—It has been well known for a number of years that the Dennis limestone of Kansas extends southward into Oklahoma where it is known as the Hogshooter formation. Named in upward order the members of this formation are: (1) Canville limestone which is a thin, local deposit; (2) Stark shale, which is largely black and fissile, only a few feet thick, and of local occurrence; and (3) Winterset limewtone, which is several feet thick and continuous across a wide region. Hence, the Winterset limestone is a key bed crossing an area of pronounced facies changes.

SUMMARY

In this paper about 300 feet of rock of late Desmoinesian and early Missourian age, in which lateral changes cause difficulty of correlation, have been briefly discussed and graphically represented.

Marmaton rocks show only slight changes in facies in this area, but Missourian rocks younger than those discussed in this paper, as well as rocks of Virgilian age, undergo definite lateral changes in places near the Kansas-Oklahoma boundary (Moore and others, 1937, Figs. 16, 19, 20, 23, 24).

The most important contributions offered in this paper are the determination of the position of the Checkerboard limestone in the southern Kansas section and the description of stratigraphic relations that bear on definition of the boundary between rocks of Desmoinesian and Missourian age in southern Kansas and northern Oklahoma.

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TERTIARY SEDIMENTS NORTHEAST OF MORGAN HILL, CALIFORNIA[1]

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INTRODUCTION

In a summary of the Eocene paleogeography of the California Coast Ranges, R. D. Reed[3] published a map showing the areas known to have been submerged during some part of the Eocene epoch and outlining the areas which were probably land throughout the Eocene. Reed showed on this map a tongue-like land mass extending southeastward from San Francisco Bay (Fig. 1). The Eocene marine sediments discussed in this paper occur in the center of this supposed land mass. Since they have not been previously reported from this part of California, the present paper is written to place on record these Eocene sediments and to describe their character and relationships. Likewise middle and upper Miocene sediments have not been previously reported in this area.

The writer has made only a preliminary reconnaissance study of the region. The stratigraphic and structural problems there are interesting and probably important enough to warrant a more extensive and detailed study, but additional field work is not possible at the present time.

[1] Manuscript received, March 19, 1943.

[2] Department of geological sciences, University of California.

[3] R. D. Reed, *Geology of California*, Amer. Assoc. Petrol. Geol. (1933), pp. 142–45.

ACKNOWLEDGMENTS

Credit is due C. A. Anderson who first discovered Eocene fossils in this area in 1941, B. L. Clark who determined the fossils collected, and N. L. Taliaferro who has offered helpful suggestions.

GENERAL GEOLOGY

Rising abruptly east of the Santa Clara Valley, the mountains of this area consist essentially of a series of ridges[4] trending northwest and southeast parallel

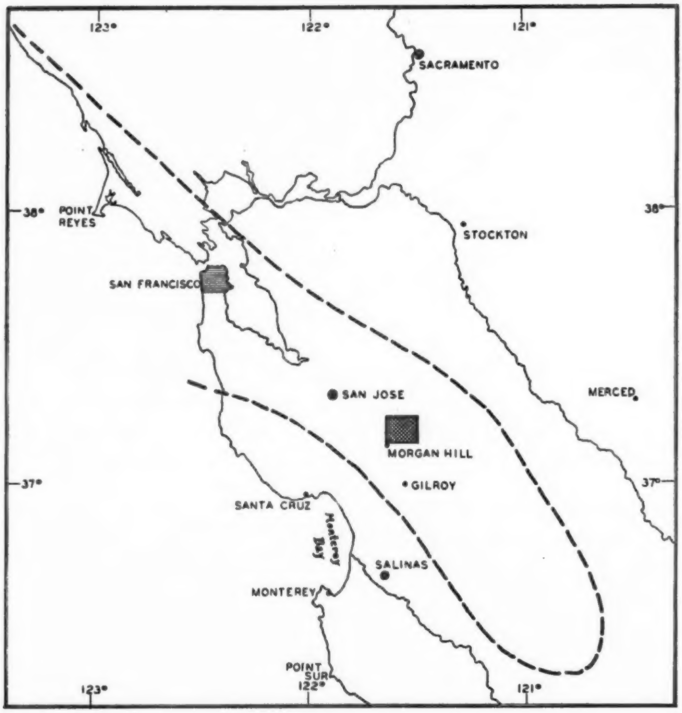

FIG. 1.—Sketch map showing location of area studied. Broken line is from R. D. Reed (1933) showing outline of probable Eocene land mass extending southeast from San Francisco Bay.

with the strike of the underlying formations. These ridges become progressively higher northeast and reach a maximum near the center of the Diablo Range. Within the area mapped by the writer the relief is as much as 1,500 feet and the slopes are steep.

[4] The area is shown on the northeast part of the Morgan Hill Quadrangle, California, published by the United States Geological Survey.

The general geologic setting is shown on the map and section (Figs. 2 and 3). Flanking the Santa Clara Valley on the east is a ridge composed of serpentine, presumably upper Jurassic in age, through which Coyote Creek has cut a gorge opposite the town of Madrone. The westward extent of the serpentine is obscured by alluvium in the Santa Clara Valley; its eastern contact is the Hayward fault zone.

In contact with the serpentine along the Hayward fault is a series of incoherent

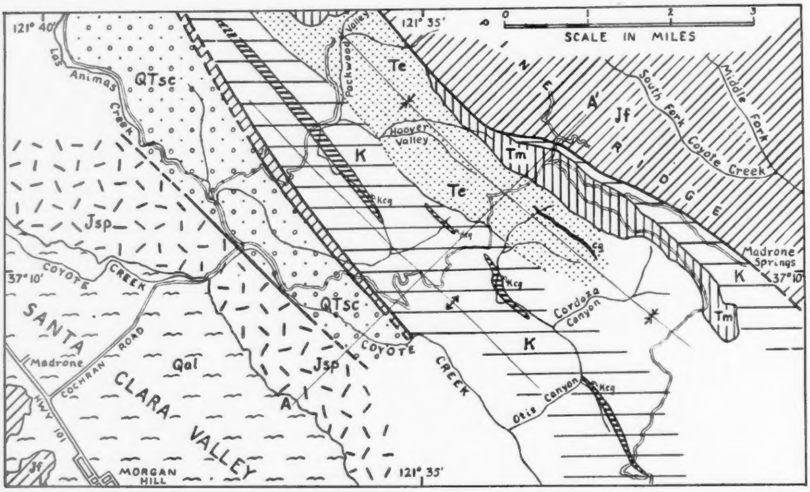

FIG. 2.—Geologic sketch map of area northeast of Morgan Hill, Santa Clara County, California. *Qal*—Recent alluvium. *QTsc*—Plio-Pleistocene Santa Clara formation. *Tm*—middle Miocene sandstones, shales, and limestones. *Te*—middle (and upper?) Eocene sandstones and shales with conglomerate lenses (*cg*). *K*—Cretaceous shales and sandstones with conglomerate lenses (*Kcg*). *Jf*—upper Jurassic Franciscan formation. *Jsp*—upper Jurassic serpentine.

reddish and greenish siltstones, sandstones, and conglomerates, tentatively regarded as the equivalent of the Plio-Pleistocene Santa Clara formation found farther northwest. The reddish character of many of the beds and the very irregular bedding, especially in the conglomerates, suggest a continental deposition for this series. No fossils have been found in it to the writer's knowledge, but the conglomerates contain débris of the middle Miocene shales and limestones exposed farther east and the series is thus the youngest mapped by the writer in this area. Dipping northeastward at low or moderate angles, these beds are cut off along a major fault zone, regarded as the southern extension of the Calaveras fault.

Franciscan rocks, exposed in a long narrow band within the Calaveras fault zone, consist of serpentine, glaucophane schist, red chert, sandstone, and shale.

The fault bounding the zone on the east has considerable topographic expression, in the form of sag ponds and hillside troughs, suggesting recent movement along it. This and the Hayward fault converge to the southeast and may join near the dam constructed across Coyote Creek,[5] a little south of the area mapped by the writer.

East of the Calaveras fault a series of Cretaceous sediments dip steeply southwest toward the fault and are cut off along it. No fossils have been found in these sediments so that they are referred to the Cretaceous period wholly on a lithologic basis and because they lie below known Eocene sediments farther east. The series consists of dark gray, silty, carbonaceous shales, thin beds of fine-grained arkosic sandstone, and numerous dark gray limestone nodules. Here and there within the series is thick-bedded arkosic sandstone containing abundant flakes of biotite. Some conglomerate lenses of considerable extent are shown on the map (Fig. 2). Most of the boulders and pebbles in these conglomerates are composed of probably pre-Franciscan rocks—porphyries, quartzite, gneiss, and granitic rocks—but cobbles of limestone similar to that in the Cretaceous itself are common and several pebbles regarded as Franciscan chert were found. At least one glauconitic sandstone occurs in the series but it could not be satisfactorily mapped. Approximately 5,000 feet of these Cretaceous sediments are exposed. They occur in an anticline and are overlain at the east by Eocene sediments folded into a parallel syncline.

The Eocene sediments are overlain at the east with marked angular unconformity by Miocene beds folded into a shallow syncline. East of these Miocene sediments, along the southern part of their outcrop, older sandstones and shales dipping steeply southwest are again exposed. These older beds are designated as Cretaceous on wholly lithologic grounds, and there may be reasonable doubt about their age. They may be Eocene but the writer was impressed in the field with their seemingly greater similarity to the Cretaceous rocks farther west.

The entire northeastern part of the mapped area is underlain by the Franciscan formation of upper Jurassic age which is thrust over the Cretaceous and Tertiary sediments along a major fault which dips steeply northeast. Arkosic sandstones and sheared dark shales are the predominant rock types in the Franciscan of this area but some lenses of red and green chert and a few small intrusions of altered basalt were mapped.

EOCENE SEDIMENTS

In a region of considerable relief and steep slopes such as this the bedrock exposures are surprisingly poor. As a result no very detailed section through the Eocene series could be measured. Within the area underlain by Eocene rocks most of the stream valleys are alluviated and on the grassy soil-covered slopes

[5] G. D. Louderback, "Characteristics of Active Faults in the Central Coast Ranges of California with Application to the Safety of Dams," *Bull. Seismol. Soc. America*, Vol. 27, No. 1 (January, 1937), pp. 25–26.

only the more resistant sandstone and conglomerate members of the series are exposed. These are sufficiently numerous to permit the measurement of a maximum exposed thickness of 2,300 feet for the series. Since no evidence of extensive faulting within the formation was noted a continuous series approximately 2,300 feet thick is probably present.

The Eocene sediments include, as well as the resistant sandstones and conglomerates, a great aggregate thickness of less resistant, thin-bedded siltstones and shales which are exposed here and there in gullies and along the roads. Generally brown or dark gray and carbonaceous, these shales and siltstones are similar in character to the finer sediments of the underlying Cretaceous series, except that limestone nodules common in the Cretaceous are scarce in the Eocene. The more resistant sandstones of the Eocene are thick-bedded and arkosic and scarcely distinguishable from those of the Cretaceous. Conglomerate members are certainly much less common in the Eocene than they are in the Cretaceous. Only one Eocene conglomerate is sufficiently extensive to be mapped and this one is much finer-grained and contains more numerous limestone pebbles than do those in the Cretaceous series.

The basal part of the Eocene series is hard sandstone and pebbly conglomerate which is fossiliferous where it crosses the road leading to Pine Ridge. Fossils were also collected from this horizon here and there within a mile northwest of the road. Fortunately this basal sandstone can be followed continuously for considerable distances and of all the Eocene horizons it is the only one lithologically distinct from the Cretaceous sediments. Were it not for this the separation of the two series would be next to impossible. Even so the base of the Eocene beds is certainly known only where the contact is shown as a solid line on the map (Fig. 2). In Cordoza Canyon where exposures are better than elsewhere and continuous, the writer was unable to find any evidence of the contact between the two series. Presumably the Eocene sediments extend southeastward across this canyon and the road south of it, though it is also conceivable that the syncline in which the Eocene rocks occur plunges northwestward and that the basal contact of the Eocene closes near Cordoza Canyon. Because no separation between the two series here could be established, the map is not completed in this area. Likewise, east of Cordoza Canyon and along the road to Pine Ridge on the east side of the syncline, the base of the Eocene could not be established. It may be concealed beneath the overlying Miocene sediments, and on this supposition the older sediments between the Miocene and Franciscan formation on the east are mapped as Cretaceous.

The only Eocene fossils found occur in the basal sandstone near the road leading to Pine Ridge. The distinctive forms include: *Turritella andersoni lawsoni* Merriam, *Cryptochordia californica* var. (Cooper), and *Discocyclina* sp. In addition to these, there are numerous small pelecypods and very abundant fragments of carbonized wood. The sandstone in which these fossils occur is light gray in color and arkosic. It contains little biotite but very abundant chips of dark shale.

supposedly derived from the underlying Cretaceous beds. Here and there it is very firmly cemented with calcium carbonate, and the fossils are most abundant and best preserved in these well cemented zones. West of Packwood Valley the basal part is a thin unfossiliferous conglomerate. It contains, as the coarse constituents, pebbles of Cretaceous shale and limestone and boulders composed of limestone nodules.

Since fossils could not be found above the basal part it is not known what stage of the Eocene may be represented by the higher beds exposed in this area. The base of the series is apparently middle Eocene, Domengine, or Capay, showing that the early Eocene seas did not cover this region.

A break between the Cretaceous and Eocene deposits is clearly indicated by the mapping of the conglomerate lenses in the Cretaceous series. The Eocene beds overlap onto slightly lower beds in the Cretaceous as the contact is followed northwestward. However, the unconformity between the two is not structurally marked and the attitudes in the two series are practically identical.

MIOCENE SEDIMENTS

The basal part of the Miocene sediments shown on the map (Fig. 2) is coarse sandstone and pebbly conglomerate containing an abundant pelecypod fauna, including: *Mytilus midendorfi* Grewingk, *Pecten andersoni* Arnold, and *Pecten propatulus* var. Conrad. The base of the series is, therefore, probably middle Miocene in age and generally called the Temblor formation. This sandstone and conglomerate zone varies in thickness and is considerably thinner on the north. Upward in the section the sandstone grades into siliceous and calcareous shales containing abundant lenses of impure limestone. Approximately 1,000 feet of sandstone and shales are exposed.

North of Packwood Valley, a little beyond the limits of the map (Fig. 2), the middle Miocene shales are overlain by coarse-grained calcareous sandstone and conglomerate. Some pebbles derived from the Miocene siliceous shales and limestones occur in these conglomerates which are, therefore, probably disconformable on the underlying shales. Very abundant pelecypods found in these upper sandstones and conglomerates include the following: *Tivela gabbi* Clark, *Tivela diabloensis* Clark, *Chione panzana* Anderson and Martin, and *Pseudocardium* (com.) *pabloensis* Packard. None of the forms collected is distinctive but the fauna suggests to B. L. Clark who determined the fossils that these sandstones and conglomerates are uppermost Miocene rather than Pliocene in age. They are probably equivalent to part of the San Pablo formation found farther north in the Diablo Range or to the Santa Margarita formation of the Santa Cruz Mountains on the west.

STRUCTURE

The structural details of a region complicated by the folding and the major faults shown on the map (Fig. 2) could be understood only after careful mapping

of a more extensive area than is covered in this paper. Only one feature is considered here, the relation between the syncline in the Eocene series and the adjacent syncline in the Miocene. No anticline between the two is evident in the field, even in Cordoza Canyon and along the road south of it where exposures are continuous, nor was evidence of important faulting between the two synclines observed in the field. It is clear that a pronounced angular unconformity separates the Eocene and Miocene sediments, and it is probable that after the folding,

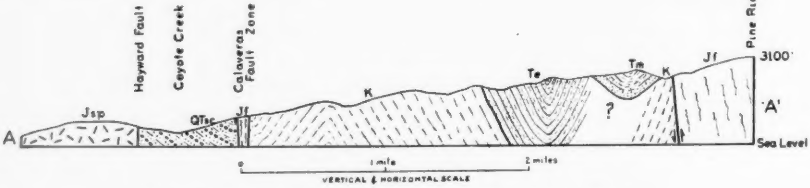

FIG. 3.—Geologic structure section along line AA' on Figure 2.

and possibly faulting, which followed the Eocene deposition and preceded the middle Miocene deposition, the area was deeply eroded. The Miocene sediments may have been deposited locally on this erosion surface or they may have spread widely across it, but when post-Miocene folding occurred the synclinal axis developed (at least the one still evident) did not coincide with that developed by post-Eocene folding. The two synclines converge toward the northwest and they may coincide a little north of the limits of the map. Such an interpretation implies a major structural break between the Eocene and Miocene sediments of this region. Admittedly there is no clear indication in the field of the structure concealed beneath the Miocene deposits and none is suggested on the section (Fig. 3).

TWO DEEP WATER WELLS NEAR RAPID CITY, SOUTH DAKOTA[1]

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Two deep water wells were drilled at the Rapid City, South Dakota, Airport during 1942. Inasmuch as these are the first deep wells to be put down close to the east edge of the Black Hills uplift, they offer an opportunity to compare the stratigraphy and structure as observed in outcrops with that present below the surface a few miles east.

[1] Manuscript received, March 6, 1943.

[2] Associate professor of geology, South Dakota School of Mines and Technology.

Well No. 1, located 1,400 feet east of the west line and 57 feet south of the north line of Sec. 18, T. 2 N., R. 9 E., Pennington County, South Dakota, was started in the Pierre shale and finished at 4,645 feet in the basal Pahasapa or upper Englewood limestone of Mississippian age. The elevation of the top of the Kelly bushing was 3,194.85 feet. The casing consists of 368 feet of 16-inch (outside dimension) pipe set at 370 feet, and 4,288 feet of 9-inch set at 4,645 feet. The static level of Pahasapa water was approximately 543 feet below the casinghead; the temperature of the water was 121°.

Well No. 2 is 1,480 feet east of the west line and 2,438.8 feet south of the north line of Sec. 13, T. 2 N., R. 8 E., or 5,200 feet west and 2,372 feet south of well No. 1. The elevation of the top of the Kelly bushing was 3,210.4 feet. The casing consists of 986.76 feet of $13\frac{5}{8}$-inch set at 1,000.76 feet and 3,191.84 feet of 7-inch set at 4,180 feet. Manning and Martin, Inc., of Denver, Colorado, drilled both wells with rotary equipment. The sample log and record of drill-stem tests of well No. 2 is appended.

Stratigraphy.—A comparison is possible of the upper Paleozoic section in these wells, that in the Rapid City water wells 10 miles southwest, and the outcrops 10–16 miles west of the airport.

The bottom 16 feet of well No. 1 penetrated pinkish limestone assigned to the Englewood formation. The thickness of the Pahasapa limestone is nearly 300 feet in the outcrops along the east flank of the Hills and in the city wells, and increases to 400 feet in Airport well No. 1. The overlying Minnelusa formation shows the greatest change. In outcrops the formation consists of 400–550 feet of sandstone, including lesser amounts of dolomite and some thin red shales. In the city wells as much as 660 feet of this formation has been encountered, the greater thickness being due to increased dolomite and red shale beds, and the presence of several thin layers of anhydrite and gypsum. In the airport wells, where a similar thickness is present, the sandstone has largely given way to dolomite, and the red shale and anhydrite are more abundant. The formation thus resembles that encountered in the Gypsy's Hunter well No. 1,[3] 45 miles farther east more closely than it does the outcrop section. The Opeche red shale shows 90–100 feet in outcrop measurements, but typically as much as 135 feet in near-by wells, and 120–130 feet in the airport wells. The Minnekahta limestone is reported as varying from 30 to 50 feet in outcrops, but is consistently between 50 and 60 feet thick in wells along the eastern edge of the Black Hills.

The Spearfish redbeds are difficult to measure at the outcrop, and have been variously reported as thick as 695 feet along the east flank of the Hills. It is believed that such excessive thicknesses may include part of the basal Sundance formation, up to and including the red "Entrada" zone. Three hundred forty-eight feet of redbeds are present in Rapid City well No. 5, the only city well to penetrate the full Spearfish section, and 340 feet are present in each of the airport

[3] Max Littlefield, "Log of Wildcat Well in Pennington County, South Dakota," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 23, No. 8 (August, 1939), p. 1234.

wells. That this rate of thinning increases eastward is evidenced by a thickness of only 183 feet in the Gypsy well.

No near-by wells penetrate the Jurassic beds, but measured by outcrop standards, the Sundance, Unkpapa, and Morrison section is exceptionally thick. In the airport wells, each formation appears to approach its maximum known local thickness, whereas in general if one of the three formations is thick the others are relatively thin, so that the total thickness for the Jurassic is ordinarily 400 feet.

The Lakota-Fuson-Fall River (Dakota) series is comparable in all respects with near-by outcrops. The overlying Benton shales have been difficult to measure in all outcrops, and are somewhat thinner than anticipated. The Graneros shale shows a well developed Newcastle sand member, but the upper shale is about 100 feet thinner than the figure given in Folio 219.[4] The Carlile shale ranges from 100 to 350 feet thinner than previously thought, even when allowance is made for the difficulty in choosing the contact between the sandy, calcareous lower beds of the Carlile and the underlying Greenhorn formation. The Niobrara chalk approximates the 200 feet ordinarily assigned to it.

Structure.—These wells are of interest structurally because they further emphasize the sharpness of the folding along the eastern flank of the Black Hills. The Fall River (Dakota) sandstone, which has a 20° eastward dip at its outcrop 7 miles west of well No. 2, lies only 2,100 feet lower in the latter. The same formation dips eastward at a rate of only 50 feet to the mile between well No. 2 and well No. 1, and from the airport east to the Gypsy well the drop averages 26 feet to the mile.

The dip on the top of the Minnekahta limestone between the two airport wells is only 35 feet to the mile.

RAPID CITY AIRPORT WELL NO. 2

Drilled, July–October, 1942, for City of Rapid City, South Dakota
Depths in Feet

Surface	
0–14	Top of Kelly bushing to cellar floor
Pierre formation (14–625)	
–290	Shale, gray, no samples
–340	Shale, bentonitic, medium to dark gray, micaceous; with fish remains and other fossils
–380	Shale, silty, medium gray, with dark gray sideritic concretions; fossiliferous
–430	Shale, very bentonitic, medium to dark gray, waxy to translucent, micaceous, with sideritic concretions; fossiliferous
–600	Shale, silty, more or less bentonitic, medium gray, micaceous, with sideritic concretions; some layers calcareous; fossiliferous
–625	Shale, very bentonitic, medium to dark gray, translucent, micaceous; fossiliferous
Niobrara formation (625–820)	
–700	Shale, very bentonitic, medium to dark gray; some layers calcareous, with white specks elongate parallel with bedding
–820	Shale, calcareous, medium gray, speckled
Carlile formation (820–1190)	
–910	Shale, silty, slightly calcareous, medium gray, micaceous, pyritic
–930	Shale, calcareous, medium gray; interbedded with siltstone, white, micaceous, glauconitic, carbonaceous
–950	Shale, as above; no siltstone layers

[4] N. H. Darton and Sidney Paige, "Central Black Hills," *U. S. Geol. Survey Geol. Atlas Folio 219* (1925).

RAPID CITY AIRPORT WELL NO. 2—*Continued*

–1000 Shale, same; with siltstone as above; bentonite streak 980–990
–1010 Siltstone, as above; interbedded with shale, medium gray, micaceous
–1020 Shale, with siltstone as above
–1150 Shale, more or less calcareous, dark gray; with thin layers of siltstone and bentonite; some layers calcareous, speckled
–1190 Shale, calcareous, some silty; concretions, septarian with golden calcite in cracks
Greenhorn formation (1190–1300)
–1300 Shale, calcareous, some silty; streaks of limestone, brown, medium crystalline; fossiliferous
Graneros formation (1300–2105)
–1350 Shale, bentonitic, medium to dark gray, micaceous; silty streaks
–1390 Shale, medium to dark gray; some layers calcareous, speckled; numerous bentonite seams
–1440 Shale, bentonitic, slightly calcareous; medium to dark gray
–1510 Shale, medium gray to nearly black, fine, micaceous
–1700 Shale, very dark gray, flaky, micaceous
–1750 Shale, nearly black, tough, micaceous; streaks of siltstone and silty shale
–1830 Shale, medium to dark gray, micaceous; streaks of siltstone and silty shale
–1850 Sandstone, white, fine; siltstone, white; clay, hard, brown (Newcastle member)
–1990 Shale, medium to dark gray, flaky, micaceous
–2070 Shale, dark gray, tough, micaceous; streaks of siltstone and silty shale
–2105 Shale, dark gray, micaceous; streaks of white and glauconitic sandstone
Fall River (Dakota) formation (2105–2150)
–2115 Sandstone, gray to white, fine compact; streaks of light brownish gray shale
–2140 Sandstone, slightly calcareous, silty, white to gray, fine to medium, compact
–2150 Sandstone, white, medium, friable, pyritic (Water rose 1740 feet in drill stem in 32 minutes from 2095 to 2170 feet)
Fuson formation (2150–2255)
–2155 Siltstone and clay, buff to pink
–2180 Clay, silty, buff; streaks of sandstone, buff, silty
–2215 Sandstone, argillaceous and silty, fine to medium; streaks of clay, silty, yellow
–2255 Clay, gray to yellow, buff and red; some sandy; streaks of sandstone, fine, white
Lakota formation (2255–2390)
–2260 Sandstone, white, medium, friable
–2280 Clay and siltstone, red to white
–2290 Sandstone, silty, orange red (Water rose 2227 feet in drill stem in 33 minutes from 2257 to 2301. After setting 7-inch casing, and plugging back to the Lakota, casing was shot perforated between 2195 and 2320. Water then rose to within 110 feet of top)
–2330 Sandstone, white to orange, fine to medium; some partings of siltstone and clay, red to brown
–2390 Clay, gray to buff and orange; some thin streaks of sandstone
Morrison formation (2390–2620)
–2420 Clay, some sandy, greenish gray and orange; some thin sandstone streaks
–2430 Clay, sandy, greenish gray to maroon
–2510 Clay, vari-colored but dominantly greenish gray, waxy; some streaks of sandstone with greenish gray clay in interstices, some glauconitic; clay becomes sandier toward base
–2530 Same, with streaks of brown clay and some calcareous gray silty shale; some thin limestone streaks
–2620 Clay, silty to sandy, greenish gray; with zones of sandstone and siltstone, glauconitic, white
Unkpapa formation (2620–2700)
–2700 Sandstone, silty, glauconitic, white, fine to medium, friable; with partings of vari-colored clay
Sundance formation (2700–3020)
–2900 Interbedded shale, slightly calcareous, gray; sandstone, glauconitic, medium; and limestones, sandy, thin
–2905 Sandstone, argillaceous, glauconitic, white, fine, compact
–2960 Siltstone, argillaceous to sandy, pink to red
–2980 Sandstone and siltstone, glauconitic, white to gray
–3020 Sandstone, white; interbedded with siltstone and clay, white; becoming light orange at base
Spearfish formation (3020–3360)
–3360 Siltstone and clay, brick red to brown; some zones sandy; with streaks of anhydrite
Minnekahta formation (3360–3410)
–3410 Limestone, gray to cream, dense to finely crystalline
Opeche formation (3410–3530)

RAPID CITY AIRPORT WELL NO. 2—*Continued*

–3420	shale, silty, maroon to chocolate brown
–3520	Shale, silty to sandy, brick red to brown
–3530	Sandstone, very argillaceous, reddish orange; many large rounded Minnelusa grains, poorly sorted, coherent
Minnelusa formation (3530–4205)	
–3540	Anhydrite, white, finely crystalline
–3560	Clay, calcareous, sandy, white, becoming increasingly sandy toward base
–3575	Sandstone, calcareous, white, medium, compact
–3580	Dolomite, brownish gray, finely crystalline
–3585	Sandstone, white, medium, compact to friable
–3620	Dolomite, light brown to white, finely crystalline; with streaks of anhydrite
–3645	Same, with thin partings of red shale
–3655	Shale and siltstone, red to brown, soft
–3670	Sandstone, dolomitic, white to pink, poorly sorted
–3685	Sandstone and sandy dolomite; with coarse (1.5 mm.) quartz grains and red sandy siltstone (Drill-stem test of this sand below a packer at 3647 showed no water)
–3705	Dolomite, white to light pink, yellow and brown, finely crystalline
–3710	Shale, dolomitic, some sandy, red to orange; with some red sandstone, siltstone and anhydrite
–3715	Dolomite, sandy, white to orange; anhydrite, pink to white, crystalline
–3738	Shale, red; with streaks of anhydrite and dolomite
–3755	Dolomite, white to light brown, finely crystalline
–3780	Anhydrite, white, crystalline; with streaks of sandstone, white, fine, in lower part
–3790	Sandstone, dolomitic, white, medium to fine, porous
–3805	Anhydrite, white, finely crystalline
–3844	Sandstone, dolomitic, white, friable to compact, porous (Water rose 3118 feet in drill stem in 30 minutes from 3778 to 3825 feet)
–3847	Shale, red to chocolate
–3870	Interbedded dolomite, pink; sandstone, white to pink; red siltstone and shale
–3950	Interbedded anhydrite, dolomite, red shale and siltstone
–3955	Sandstone, dolomitic, pink; dolomite, pink, sandy to silty
–3960	Shale, bright red, tough, drills into thin slivers (Red marker of Lance Creek field?)
–4030	Sandstone, dolomitic, white to pink; interbedded with dolomite, white to light brown, finely crystalline, some sandy
–4070	Dolomite, medium gray to light brown, finely crystalline; with sandstone, dolomitic, white to pink, fine to medium, poorly sorted
–4090	Dolomite, white to light brown, finely crystalline; with sandstone, dolomitic, white to pink, fine to medium, poorly sorted
–4100	Sandstone, dolomitic, white to pink, poorly sorted; with streaks of sandy dolomite
–4150	Dolomite, light brown to white, fine to medium crystalline; scattered quartz crystals
–4205	Limestone, dolomitic, light brown and yellow to nearly white, with streaks of sandy red shale
Pahasapa (Madison) formation (4205–4436 T.D.)	
–4230	Limestone, white to light brown, fine to medium crystalline; some porosity
–4310	Limestone, white to very light brown and gray, dense to medium crystalline; some porous streaks
–4345	Dolomite and limestone, dolomitic, pinkish to light brown and gray, fine to medium crystalline; some porous zones
–4405	Dolomite, light brown to pink, medium crystalline, compact to very porous
–4436	Dolomite, light brown to gray with pinkish cast, medium crystalline, some very porous
–4436	Total depth of well

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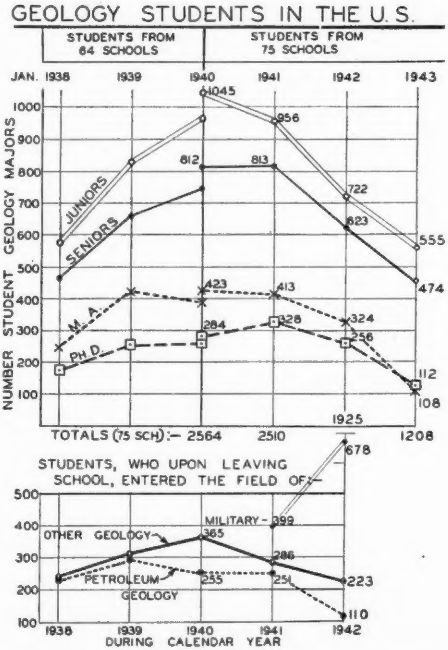
RESEARCH NOTE

SURVEY OF GEOLOGY STUDENTS[1]

A. I. LEVORSEN[2]
Tulsa, Oklahoma

Chart showing the number of college students currently majoring in geology and the placement of those leaving school during the calendar year 1942. The figures are as of January, 1943.



The enrollment trends continue downward and the total number of students is approximately half of the number 2 years ago. The increase in number of those entering the military services is continuing and the following paragraph from a letter (dated March 20, 1943) from the chairman of one of the larger geology departments expresses a condition which is probably common to many of the colleges of the country.

> A situation has slowly grown within the last year that I believe now to be quite alarming. . . . Our *entire* male student population in geology both in the engineering school and in the college has been slowly but surely forced into one or another of the enlisted reserves. By the middle of the summer we will have *no male students* of geology and only two women. That means that for the duration of the war and for approximately 3 or 4 years after the war the University of .... will furnish no replacements for the petroleum industry. I have checked with a large number of other universities and this situation is practically universal in the United States.

[1] Manuscript received, April 14, 1943.

[2] Chairman, research committee.

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REVIEWS AND NEW PUBLICATIONS

* Subjects indicated by asterisk are in the Association library, and are available, for loan, to members and associates.

THE CHEMICAL TECHNOLOGY OF PETROLEUM, BY WILLIAM A. GRUSE AND DONALD R. STEVENS

REVIEW BY BENJAMIN T. BROOKS[1]
New York, N. Y.

The Chemical Technology of Petroleum, by William A. Gruse and Donald R. Stevens. 2d ed. (1942). 720 pp. McGraw-Hill Book Company, New York, N. Y. Price, $1.00.

Since the first edition of this work, published in 1928, a great amount of scientific and technical material has been published relating to petroleum and the authors have done well, as indicated by the present new edition, in keeping up with this progress. The present volume contains excellent discussions of such subjects as Isomerization, Alkylation, Hydrogenation, and such important subjects as Cracking are brought up to date.

When so many recent technical books have evidently been the result of painstaking compilation by a group of library readers whose names do not appear as the authors, it is gratifying to note that in this case certain chapters appear under the names of the contributors, for example, the excellent chapter on Physical Properties, by J. R. Bowman, the chapter on Production Chemistry, by H. T. Kennedy, the chapter on Distillation, by J. R. Bowman, and the chapter on Thermodynamics of Petroleum Hydrocarbons, by C. W. Montgomery and J. H. McAteer. It is much easier to produce a bulky, voluminous compilation, in more or less mechanical fashion by library searching than it is to write a well considered, relatively small volume, such as the present one. The present reviewer believes that this volume could well be used as a University text in courses in petroleum engineering. In the reviewer's opinion, this work contains fewer inaccuracies than usual in a work of this scope, although curiously enough, there seem to be more inaccuracies in the chapter on Refining by Chemical Methods, than in other chapters.

The authors have given extensive literature references, and although there is little material in it of direct interest to petroleum geologists it does give a basis for an excellent understanding of chemical technology, which is the intended scope of the book.

[1] Chemical engineer, 114 East Thirty-second Street. Manuscript received, March, 1943.

THE PHYSIOGRAPHY OF VICTORIA, BY E. SHERBON HILLS

REVIEW BY BURTON WALLACE COLLINS[1]
Auckland, New Zealand

The Physiography of Victoria: An Introduction to Geomorphology, by E. Sherbon Hills, lecturer in geology in the University of Melbourne. xx+292 pp., 351 figs., frontispiece and end-piece, geological and physiographical maps. Whitcombe and Tombs Pty. Ltd., Melbourne (1940). Price 9s. 6d. (N.Z.).

The state of Victoria in Australia is of particular interest to petroleum geologists since the Lakes Entrance area in Gippsland, about 200 miles east of Melbourne, provides the only field in the sub-continent where payable quantities of oil have so far been found. Within the last two years the Commonwealth Government arranged for two American experts on low-pressure fields to visit the district and report on the best method of working

[1] P. O. Box 10, Auckland, New Zealand. Manuscript received, March 8, 1943.

the field. The sinking of a 1,200-foot shaft with a work chamber 25 feet in diameter at the bottom, and the drilling of 20–24 horizontal wells following the oil sand and each about ½ mile in length was recommended. It was estimated that "it would take six months to sink a shaft and get it into production by this method." Since the publication of the experts' report in the newspapers no further news of operations in the area has reached the writer.

The oil-bearing rocks at Lakes Entrance are Tertiary in age. The Holland's Landing bore, 4,004 feet deep (in which 3,524 feet of Tertiary rocks were proved), was the deepest well drilled in Gippsland to March, 1941.[2] Jurassic bedrock (fine-grained feldspathic sandstone and carbonaceous shale) was entered at 3,949 feet.

The Tertiary section was the thickest penetrated in Gippsland borings, and included friable sandstone, sandy shelly marls, polyzoal marls and marly limestones, fine-grained foraminiferal marls, lignitiferous sands, and brown coal. Paleontological study of the bore samples by Miss Irene Crespin, Commonwealth Palaeontologist, "revealed the most complete sequence of Tertiary beds in Gippsland. It was drilled in the deepest portion of the Tertiary basin, which occupies an area approximately parallel to the Ninety Mile Beach."[3] The age of the beds ranges from pre-Anglesean (pre-Upper Oligocene) to Kalimnan (lower Pliocene). The sands between 36 feet and 393 feet contained no distinctive fossils and are designated merely post-Kalimnan.

Dr. Hills' book on *The Physiography of Victoria* will give those interested a background against which to view these and any further facts about petroleum exploration or production in the state, as well as a concise summary of its physical geography, for he includes a chapter on "The Growth of Victoria" which is an outline of the geological history of the state.

Although definitely intended for Victorian students and teachers the book should have a much wider appeal—both among the general public and among geologists and geographers abroad.

For examples to illustrate his sixth chapter, "Processes in the Arid Cycle" (18 pages), the author has been fortunate to be able to draw upon the many arid and semi-arid regions in Australia, especially the Mallee district of North-west Victoria—described as a typically *areic* region. The term *endoreic* is used to describe the inwardly directed drainage systems of the independent basins characteristic of certain semi-arid regions. Several pages (and some good illustrations) are devoted to a description of the work of wind, and of the various types of sand dunes and ridges. "The crescent-shaped ridges, composed of fine porous clay-loam, that occur on the eastern shores of the lakes and swamps" in certain districts of the Murray Valley in northern Victoria "are pictured as having been slowly built up by the deposition of dust carried down by spray from the lakes and flooded swamps during summer dust storms, or blown up from the lake beds in dry seasons. These ridges, which may be termed *lunettes*, have regular and smooth contours quite unlike those of sand dunes."

Chapter X is a short but masterly account of "Drainage Modifications by Lava Flows" (7 pages)—especially interesting is the section on the development of twin lateral streams along the margins of a lava flow partially filling a valley and the subsequent development of lava residuals on the intervening ridge—a process termed by Cotton "volcanic inversion of relief."

The two final chapters, "The Physiographic Divisions of Victoria" (33 pages) and "The Growth of Victoria" (8 pages), will probably have the greatest appeal to American and other non-Australian readers. In Chapter XIII Dr. Hills has most successfully accom-

[2] Irene Crespin, "Palaeontological Review of the Holland's Landing Bore, Gippsland," *Mines Dept. Victoria, Mining and Geol. Jour.*, Vol. 2, No. 4 (March, 1941), pp. 252–56.

[3] Crespin, *op. cit.*, p. 252.

plished a task which has not yet been attempted for any other state in Australia or for New Zealand—a regional survey of the physiographic features of the state. Nineteen physiographic provinces are recognized and described, classified into five major groups: the Murray Basin Plains, the Central Highlands, the Western District Plains, the Gippsland Plains, and the Southern Uplands. The geological structure of each province, as well as its topographic evolution, is referred to. Several excellent block diagrams and sketch maps, in addition to photographs, illustrate the chapter.

The final chapter gives an all-too-brief account of the geological history of Victoria since the Cretaceous period from the physical point of view. The emphasis is on changes of relative level of land and sea, climate, and the effects of erosion.

Finally, reference must be made to the maps which form the end-papers of the book. These are on a scale of about 70 miles to the inch, perhaps slightly bare of place-names, but well drawn and admirably clear. One is a simplified geological map of Victoria—symptomatic of the general geological, rather than geographical, bias evident throughout the book. The other is of the physiographic divisions of the state described in Chapter XIII, clearly distinguishing plains and highlands, and by its juxtaposition to the geological map well calculated to impress on the reader the significant dependence of the various types of topography on the surface geology of the different regions. While on the subject of maps it may be permissible to quote Dr. Hills' commendable statement that "in order to understand the reasons for the existence of the different topographic features of a region, it is necessary to have a general idea of its geological structure, and a geological map should always be consulted if it is available." In a footnote to this sentence it is mentioned that a geological map of Victoria on a scale of 16 miles to the inch is available at 2s. 6d. from the Geological Survey of Victoria, Melbourne. The reviewer can also recommend this map, which is very detailed and excellently printed in 14 colors (compiled and drawn in 1936).

THE ORIGIN OF THE CAROLINA BAYS, BY DOUGLAS JOHNSON

REVIEW BY JOHN L. FERGUSON[1]
Tulsa, Oklahoma

"The Origin of the Carolina Bays," by Douglas Johnson. *Columbia Geomorphic Series*, No. IV. 341 pp. including index, plus acknowledgments, table of contents, list of illustrations, and tables. Columbia University Press, New York (1942).

"The Carolina Bays are without doubt one of the most remarkable geomorphic features on the surface of the Earth. They share with submarine canyons the distinction of being among the most difficult of earth forms to explain." With this statement, Douglas Johnson concludes the first extensive research into a recent and fascinating geological problem.

The Carolina Bays burst into prominence at the Geological Society of America meeting, December, 1942, when King Hubbert presented for Frank Melton and William Schriever a paper entitled, "Meteorite Scars in the Carolinas." In February, 1933, Melton himself presented the data and conclusions before the Tulsa Geological Society, and they were published by Melton and Schriever in *The Journal of Geology* in January-February, 1933. The basis for this paper was close examination of airplane photographs of the coastal belt of South and North Carolina, on which were revealed a myriad of smoothly oval areas with sub-parallel main axes oriented northwest and southeast, enclosing swampy deposits and generally limited by sand ridges on the southeast rim. After investigating and discarding more normal processes, Melton and Schriever ascribed the origin of the bays to scars left by an enormous shower of meteorites which hit at a low angle and plowed up the area

[1] Amerada Petroleum Corporation. Manuscript received, March 10, 1943.

into depressions which have been modified by weathering into the present "bays." The statement of this "meteorite-scar" theory gave rise to vigorous objections and the tentative suggestion of alternative explanations, none of which was well founded on factual observation.

Douglas Johnson early recognized the inherent difficulties in the problem and began a scientific research into all the avenues of approach to its solution. During the course of this study several short papers in the nature of progress reports were published, but the complete report covering a decade of research is now presented extensively in "The Origin of the Carolina Bays."

The report covers 341 pages of large easily readable type printed on heavy-coated stock which reproduces well the large number of aerial photographs, illustrating different features associated with the bays. The text is arranged in a logical manner, attacking the problems step by step. It includes ample but not excessive discussion of the many controversial points which of necessity arise in such a treatise. The illustrative material is clear and striking, the photographs of the bays being well selected and the diagrams simple and practically self-explanatory. In view of the fundamental importance of the parallelism of the bays the reviewer believes it would have been more striking if all the aerial photographs had been oriented with true north at the top of the page, even at the expense of other considerations. Also, a scale on each photograph would have been helpful and saving in written explanation.

This report is a careful and logical blending of many bits of information gleaned with infinite patience from thousands of aerial photographs, from published and unpublished reports of other investigations, no matter how remotely related to the problem, from scattered field research carried on under very trying and laborious conditions, and from laboratory experiments simulating natural conditions. Using this assemblage of necessarily fragmental data, Doctor Johnson has built up a concise and scholarly theory to account for the physical features now found in the Carolina Bays and has presented it in a clear and easily understandable style.

The presentation starts with a historical sketch of the development of the problem, presents the salient facts of the physical features of the bays, states and refutes the previous hypotheses in regard to their origin, and concludes with Johnson's hypothesis of complex origin "the artesian-solution-lacustrine-aeolian hypothesis."

In view of the sensational reaction to the "meteorite-scar" hypothesis of Melton and Schriever, and its subsequent acceptance by other geologists as well as the public, Johnson has devoted 100 pages to a clinically exact dissection and utter disintegration of this never-too-vigorous theory. As an indication of the completeness of this destruction, he devotes 20 pages of reasoning against the validity of some inconsequential magnetometer data which should have been dismissed with a paragraph.

Upon the solid foundation of well shattered remnants of other hypotheses, Johnson has erected his hypothesis of complex origin. This theory contends that "artesian springs, rising through moving ground-water and operating in part by solution, produced broad shallow basins occupied by lakes, about the margins of which beach ridges were formed by wave action and dune ridges by wind action."

The reviewer expected that Doctor Johnson would build up his hypothesis with as well documented and substantial evidence as he had used in refuting other hypotheses. Certainly, he has built it carefully and logically but he has erected the upper three parts on an artesian foundation which is buttressed largely with reasoning and contains little substance to support the partially constructed theory.

To the establishment of this fundamental artesian phase of his hypothesis, Johnson has devoted only 26 pages. In this space he asks and answers four questions: (1) were shallow artesian waters of common occurrence; (2) were geological conditions favorable

to escape of these waters to the surface at innumerable points over a vast territory; (3) are there indications that artesian springs were active at that place and time; and (4) are there grounds for supposing that such artesian springs could excavate basins of the Carolina Bays type? Having answered these questions in the affirmative, Johnson feels that the artesian phase of his hypothesis is well established.

To the reviewer the evidence supporting the artesian phase is weak and the logic is not sufficiently inclusive, for there still remain questions which are not satisfactorily answered. For instance, it does not appear too certain: (1) why the artesian conditions which were theoretically active as the initial force in forming the bays should not be active in the same areas now; (2) why the tremendous volumes of water necessary to produce and maintain the bays under this hypothesis failed to develop prominent stream lines; (3) why the puncturing of innumerable great holes in the impervious cap of the hypothetical artesian aquifer did not reduce the hydrostatic head so that the artesian spring would fail to reach the surface farther down-slope; (4) how a condition could exist which would permit artesian water to rise abundantly to the surface through formations saturated with flowing ground water and yet permit an equally abundant outflow through sinkholes in the same saturated formations.

Because of such unanswered questions regarding the artesian phase of the hypothesis, the logic of the whole hypothesis is weakened. Nevertheless, the reviewer believes that the hypothesis represents a distinct advance in the thinking in regard to these extraordinary land forms. Certainly, ground water, lakes, wind, artesian water, and solution have had their places in the origin of the bays. The main problem is to put them in proper sequence and give them proper weight, but additional factual data must be presented before this can be done successfully.

"The Origin of the Carolina Bays" is a masterpiece of deductive reasoning and it is to be hoped that the exceedingly difficult, laborious, and expensive field work which must eventually be done will confirm in large part Douglas Johnson's reasoning as the correct solution of this fascinating problem.

MARINE ECOLOGY AS RELATED TO PALEONTOLOGY, BY HARRY S. LADD, CHAIRMAN

"Report of the Committee on Marine Ecology as Related to Paleontology, 1941–1942," by Harry S. Ladd, chairman. National Research Council Division of Geology and Geography, Washington, D. C. 58 mim. pp. 8.5×11 inches. Price, $0.50.

The report for 1941–1942 of the committee on marine ecology as related to paleontology has recently been issued by the National Research Council. It is a bound mimeographed bulletin of 58 pages, containing material presented last May at the annual meeting of the Division of Geology and Geography. It is similar to the report of the subcommittee on the ecology of marine organisms issued a year ago.

The report gives information on current and recently completed activities together with a current bibliography and summary reviews. Included also are seven signed reports dealing with special ecologic studies. The Division of Geology and Geography believes the report will be found useful by paleontologists. Complimentary copies have been sent to contributors but the Division is unable to distribute such copies as widely as heretofore. Requests for copies should be addressed to the Division of Geology and Geography, National Research Council, 2101 Constitution Avenue, Washington, D. C., accompanied by a remittance of fifty cents for each copy desired.

RECENT PUBLICATIONS

AUSTRALIA

*"The Devonian of Western Australia. Part II," by Curt Teichert. *Amer. Jour. Sci.*, Vol. 241, No. 3 (New Haven, March, 1943), pp. 167–84; Fig. 4.

CALIFORNIA

*"Searching for Oil in the City When Los Angeles Was Young—and Now!" by Martin Van Couvering. *Petrol. World*, Vol. 40, No. 3 (Los Angeles, March, 1943), pp. 42–62, 95 illus.

CANADA

*"The Algal Nature of the Genus Koninckopora Lee; Its Occurrence in Canada and Western Europe," by Alan Wood. *Quar. Jour. Geol. Soc. London*, Vol. 98, Pts. 3–4, Nos. 391–92 (London, February 15, 1943), pp. 205–23; 3 figs., 3 fossil pls.

ENGLAND

*"Stratigraphy and Structures East of Oxford," by W. J. Arkell. *Quar. Jour. Geol. Soc. London*, Vol. 98, Pts. 3–4, Nos. 391–92 (London, February 15, 1943), pp. 187–204; 4 geologic cross sections, 1 folded geologic map in colors.

EUROPE

*"Dasycladaceous Algae from the Girvan Area," by Ethel D. Currie and Wilfred Norman Edwards. *Quar. Jour. Geol. Soc. London*, Vol. 98, Pts. 3–4, Nos. 391–92 (London, February 15, 1943), pp. 235–40; 1 fig., 1 fossil pl.

GENERAL

"The Basin and Range Province in Utah, Nevada, and California," by T. B. Nolan. *U. S. Geol. Survey Prof. Paper 197-D* (February, 1943), pp. 141–96, Pls. 40–41, Figs. 10–13. For sale by Supt. Documents, Govt. Printing Office, Washington, D. C. Price, $0.15.

Geomorphology: The Evolution of Landscape, by Norman E. A. Hinds. 906 pp., 777 illus. 6×9 inches. Prentice-Hall, Inc., 70 Fifth Avenue, New York (1943). Price, clothbound, $5.00.

*"Geochemistry's Place in Future Exploration," by Robert O. Smith. *World Petroleum*, Vol. 14, No. 3 (New York, March, 1943), pp. 45–49, illus.

*"Wildcatting and Oil Reserves," by Frederic H. Lahee. *Ibid.*, pp. 30–31, illus.

*"War Demands More Oil—More Exploration," by E. L. DeGolyer. *Ibid.*, pp. 26–28, illus.

*"Accelerated Discovery through Geophysics," by L. I. Freeman. *Ibid.*, pp. 48–49, illus.

*"Report of the Committee on Marine Ecology as Related to Paleontology, 1941–1942," by Harry S. Ladd, chairman. Natl. Research Council Div. Geol. Geogr., 2101 Constitution Avenue, Washington, D. C. 58 mim. pp. 8.5×11 inches. Price, $0.50.

*"Oil Zones of the United States; Cambrian and Lower Ordovician," compiled by the *Oil and Gas Journal*, Vol. 41, No. 45 (Tulsa, March 18, 1943). 2 pp. between pp. 68 and 69; map of United States.

Map Interpretation with Military Applications, by William C. Putnam. 67 pp., 26 figs. 8.5×11 inches. McGraw-Hill Book Company, Inc., New York and London (1943). Price, $1.25.

*"Report of the Summer Quarterly Meeting Featuring Pressure Maintenance and Second Recovery." *Interstate Oil Compact Quar. Bull.*, Vol. 1, No. 2 (Interstate Oil Compact Commission, Oklahoma City, Oklahoma, July, 1942). 80 pp.

*"Report of the Autumn Quarterly Meeting Featuring Conservation and Utilization of Natural Gas." *Ibid.*, Vol. 1, No. 3 (October, 1942). 115 pp.

*"Report of the Winter Quarterly Meeting Featuring a National Survey of Stripper Wells." *Ibid.*, Vol. 1, No. 4 (December, 1942). 132 pp.

KANSAS

*"Geology and Ground-Water Resources of Ford County, Kansas," by Herbert A. Waite. *Kansas Geol. Survey Bull. 43* (Lawrence, December, 1942). 250 pp., 22 figs., 16 pls., 15 tables.

*"Geology and Ground-Water Resources of Meade County, Kansas," by John C. Frye. *Ibid., Bull. 45* (December, 1942). 152 pp., 10 figs., 12 pls., 10 tables.

*"New Carboniferous and Permian Sponges," by Ralph H. King. *Ibid., Bull. 47*, Pt. 1 (February 27, 1943). 36 pp., 2 figs., 3 pls.

ILLINOIS

*"Geologic Background of Oil Production in the Illinois Basin," by B. F. Hake. *Oil and Gas Jour.*, Vol. 41, No. 44 (Tulsa, March 11, 1943), pp. 82–86.

"Structure of Herrin (No. 6) Coal Bed in Macoupin County, East Greene and Jersey, Southeast Scott, and South Morgan and Sangamon Counties," by J. N. Payne; "Oil and Gas Possibilities," by W. H. Easton. *Illinois Geol. Survey Cir. 88* (Urbana, March, 1943). Mimeog. circular, tabulated data, planographed structure map. Price, $0.51 (10 cents extra if paid by check).

LOUISIANA

*"Lower Eocene Faunal Units of Louisiana," by John O'Keefe Barry and Rufus J. LeBlanc. *Louisiana Geol. Survey Bull. 23* (Baton Rouge, 1942). 208 pp., frontispiece, 19 pls., 5 figs., 2 tables.

NEW YORK AND ONTARIO

*"Black River Stratigraphy and Faunas. Part I," by Frederick Pentz Young, Jr. *Amer. Jour. Sci.*, Vol. 241, No. 3 (New Haven, March, 1943), pp. 141–67; 5 figs., 2 pls.

OKLAHOMA

"Subsurface Geology and Oil and Gas Resources of Osage County, Oklahoma, Part II, Summary of Subsurface Geology with Special Reference to Oil and Gas," by N. W. Bass. *U. S. Geol. Survey Bull. 900-K* (February, 1943), pp. 343–93, Pls. 13–20, Figs. 4–6. For sale by Supt. Documents, Govt. Printing Office, Washington, D. C. Price, $0.45.

ASSOCIATION DIVISION OF PALEONTOLOGY AND MINERALOGY

**Journal of Paleontology* (Tulsa, Oklahoma), Volume 17, No. 2 (March, 1943).

"The Fauna of the Pitkin Formation of Arkansas," by William H. Easton.

"Evidence on the Nature of Conodonts," by Ernest P. DuBois.

"Distinctive New Species of Foraminifera from the Cane River Eocene of Louisiana," by Keith M. Hussey.

"Conodont Fauna and Distribution of a Lower Mississippian Black Shale in Montana," by Chalmer L. Cooper and Laurence L. Sloss.

"*Paranonion*, A New Genus of Foraminifera from the Miocene of Venezuela," by L. L. Logue and M. W. Haas.

"A New Asteroid from the Jurassic of Central Wyoming," by A. K. Miller and A. G. Unklesbay.

"The Pendleton Formation, Louisiana and Texas," by Richard Wasem and Louis J. Wilbert, Jr.

"Pacific Coast Cretaceous and Tertiary Corals," by J. Wyatt Durham.

"Permian Fusulinid from Peru," by M. L. Thompson.

BULLETIN OF THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS
VOL. 27, NO 5 (MAY, 1943), PP. 659-704, 8 FIGS.

THE ASSOCIATION ROUND TABLE

WEST TEXAS GEOLOGICAL SOCIETY STUDENT MERIT AWARD

The West Texas Geological Society Student Merit Award honorees this year are George A. Williams, of Deming, New Mexico, and Bertram Wolfram, Jr., of Galveston, Texas. Each receives from the Society a paid-up 2-year associate membership in the A.A.P.G., and from the Association a copy of the cloth-bound volume of the A.A.P.G. *Bulletin* for 1942.

GEORGE A. WILLIAMS

BERTRAM WOLFRAM, JR.

GEORGE ARTHUR WILLIAMS.—Born at Wilcox, Arizona, January 14, 1918. Graduated from high school at Manfa, Texas; attended Sul Ross State Teachers College at Alpine, Texas, 1935–1937. Taught school at Casa Piedra, and at Shafter, Texas, 1938–1940. Worked for American Metals Company of Texas, mucking and mining, 5 months in 1940. Attended Texas College of Mines and Metallurgy, El Paso, Texas, 1940–January, 1943. Degree: Bachelor of Science in Mining Engineering (geology option, 35 hours). Member of Scientific Club, student associate of A.I.M.E., and member of Sigma Gamma Epsilon and Alpha Chi (honorary societies) and Alpha Phi Omega fraternity. After college, worked 3 weeks as control engineer for Kennecott Copper Corporation, Ray Mines Division, Ray, Arizona, before entering Midshipmen's Training School for Officers in the Navy.

BERTRAM WOLFRAM, JR.—Born in Galveston, Texas, February 22, 1922. Graduated from Kirwin High School, Galveston; attended St. Mary's University, San Antonio, 1 year, 1938–1939; graduated from Texas Technological College, Lubbock, May, 1943. Degree: Bachelor of Science in Petroleum Engineering (geology option, 58 hours). Active member of Sigma Gamma Epsilon, being vice-president of Alpha Beta Chapter; Society of Petroleum Engineers and Geologists of Texas Tech.; and Engineering Society, Texas Tech. Student assistant in geology department.

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REPRESENTATIVE ON DIVISION OF GEOLOGY AND GEOGRAPHY NATIONAL RESEARCH COUNCIL: M. G. CHENEY (1946)

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WESLEY G. GISH	PAUL H. PRICE
KENNETH K. LANDES	

Names of new appointees to standing committees and names of chairmen and members of special committees will appear in the June *Bulletin*

TWENTY-EIGHTH ANNUAL MEETING

THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS HOTEL TEXAS, FORT WORTH, TEXAS

APRIL 7-9, 1943

OFFICERS AND COMMITTEE CHAIRMEN

A.A.P.G.

President, F. L. Aurin, Fort Worth, Texas
Past-President, Edgar W. Owen, San Antonio, Texas
Vice-President, Paul Weaver, Houston, Texas
Secretary-Treasurer, E. O. Markham, Tulsa, Oklahoma
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Bus. Mgr., J. F. Gallie, Washington, D. C.

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Past-President, J. B. Lovejoy, Gulf Oil Corporation
Vice-President, William J. Hilseweck, Gulf Oil Corporation
Secretary-Treasurer, Richard H. Schweers, The Texas Company

CHAIRMEN ARRANGEMENTS COMMITTEES

General	Karl A. Mygdal, Pure Oil Company
Technical program	A. I. Levorsen, consulting geologist
Technical arrangements	Thomas B. Romine, Sinclair Prairie Oil Company
Hotels	Ralph H. Cummins, Cummins and Berger
Finance	Richard H. Schweers, The Texas Company
Reception	J. B. Lovejoy, Gulf Oil Corporation
Registration	William J. Nolte, Stanolind Oil and Gas Company
Educational exhibits	Herbert H. Bradfield, The Texas Company
Entertainment	David Donoghue, consulting geologist
Publicity	John S. Sparks, Fort Worth *Star-Telegram*
S.E.P.M. representative	Gayle Scott, Texas Christian University
S.E.G. representative	John H. Wilson, Independent Exploration Company

OFFICERS ELECTED AT FORT WORTH

A.A.P.G.

President: A. RODGER DENISON, Amerada Petroleum Corporation, Tulsa, Oklahoma
Vice-president: ROBERT W. CLARK, Western Gulf Oil Company, Los Angeles, California
Secretary-treasurer: ROBERT E. RETTGER, Sun Oil Company, Dallas, Texas
Editor: CAREY CRONEIS, University of Chicago, Chicago, Illinois

S.E.P.M.

President: J. HARLAN JOHNSON, Colorado School of Mines, Golden, Colorado
Vice-president: R. DANA RUSSELL, U. S. Navy Radio and Sound Laboratory, San Diego, California
Secretary-treasurer: H. B. STENZEL, University of Texas Bureau of Economic Geology, Austin, Texas

S.E.G.

President: R. D. WYCKOFF, Gulf Research and Development Company, Pittsburgh, Pennsylvania
Vice-president: W. M. RUST, JR., Humble Oil and Refining Company, Houston, Texas
Secretary-treasurer: HART BROWN, Brown Geophysical Company, Houston, Texas

"OIL AND NATURAL GAS ARE VITAL TO THIS WAR." This and an equally pertinent statement, "PETROLEUM IS REGARDED AS ONE OF THE MOST ESSENTIAL OF WAR INDUSTRIES," dominated the program of the 28th annual meeting of the Association. The place was the Crystal Ball Room of the Hotel Texas, Forth Worth, Texas, and the time was April 7, 8, and 9, 1943. Other timely quotations from recent releases of Paul V. McNutt, chairman of the Manpower Commission and Harold L. Ickes, Petroleum Administrator for War, and a particularly compelling sentence from President Roosevelt, "The Immediate Discovery of Additional Sources of Oil Is Imperative," punctuated the printed program. The serious purpose of the meeting was unescapable. It was the second war-time conference of the three exploratory earth-science groups of the oil industry: the American Association of Petroleum Geologists, the Society of Economic Paleontologists and Mineralogists, and the Society of Exploration Geophysicists.

Nearly 1,000 geologists, paleontologists, and geophysicists attended the meeting. Probably as many more would have come had not the accommodations of travel and hostelry been otherwise occupied—also in the business of winning the war. And about 500 members were absent—in military service—although warmly present in the thoughts and hearts of those at the meeting, and represented by one large blue star in the white field of the Association's service flag. The registered attendance was 712 members and 414 nonmembers.

S.E.P.M. President
J. HARLAN JOHNSON
Golden, Colorado

S.E.G. President
R. D. WYCKOFF
Pittsburgh, Pa.

The Fort Worth Geological Society, as host, welcomed the three societies and dedicated the program to the members in the Armed Forces. It extended its hospitality through a smoker and light entertainment on Thursday night, following the evening meeting in the Ball Room, and distributed a souvenir booklet containing the photographs of the Fort Worth members.

The usual four-day convention was shortened to three days of technical papers, research conferences, and business meetings. The annual banquet, dance, golf tournament, and field trips were eliminated. The convention registration and headquarters business counters were on the hotel Lobby and 14th floors respectively. The business committees and research conferences met on the Mezzanine; the technical sessions and exhibits occupied the 14th floor.

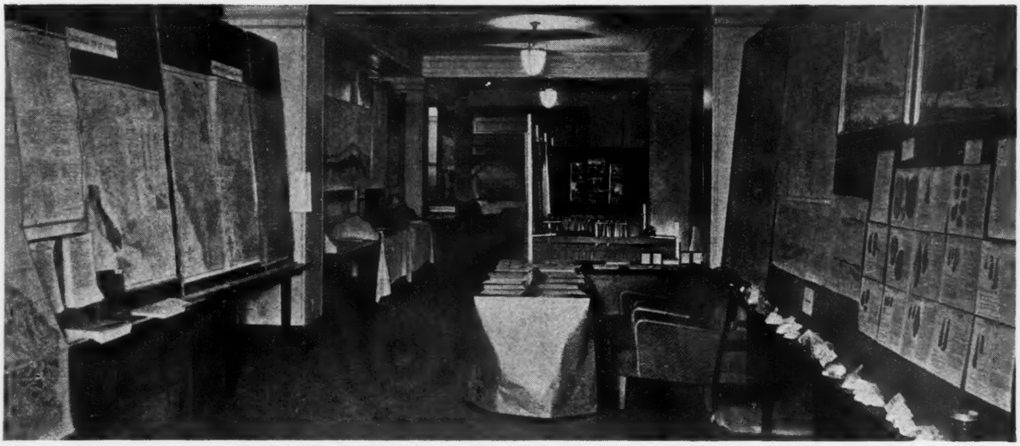
Sixteen oil-field service advertising booths filled the length of the Bluebonnet Court of the 14th floor, illustrating various methods and equipment used in oil exploration. Nearly 200 linear feet of map displays formed the educational exhibits of State geological surveys and geological societies.

Association executive committee elected at Fort Worth. Seated, left to right: Fritz L. Aurin, past-president; A. Rodger Denison, president; Robert W. Clark, vice-president. Standing, left to right: Robert E. Rettger, secretary-treasurer; Carey Croneis, editor.

Two symposia stressed the efforts of the program committee to meet current needs.

Symposium on Secondary Recovery and Stripper Wells, with Particular Reference to Geological Factors

1. George R. Elliott, Phillips Petroleum Company, Bartlesville, Oklahoma
   Geologic Factors in Unitized Pressure Maintenance, Jones Sand Reservoir, Shuler Field, Arkansas
2. Paul D. Torrey, consulting geologist, Houston, Texas
   George H. Fancher, Department of Petroleum Engineering, University of Texas, Austin, Texas



Part of educational map displays at 28th annual meeting, 14th floor, Hotel Texas, Fort Worth, Texas.

R. C. EARLOUGHER, Geologic Standards Company, Tulsa, Oklahoma
Criteria for Determining an Oil Field's Susceptibility to Secondary Recovery Methods

3. PAUL E. FITZGERALD, Dowell, Inc., Tulsa, Oklahoma
New Method of Permeability Measurement
4. C. P. McGAHA, Fain and McGaha, Wichita Falls, Texas
The Importance of the Stripper Well

Symposium on Favorable Areas for Wildcatting for War Needs

1. MAX L. KRUEGER, Union Oil Company, Los Angeles, California
Pacific Coast States
2. C. E. DOBBIN, United States Geological Survey, Denver, Colorado
Rocky Mountain States
3. J. V. Howell, consulting geologist, Tulsa, Oklahoma
North Mid-Continent and Eastern States
4. O. L. BRACE, consulting geologist, Houston, Texas
Gulf Coast and South Mid-Continent

The paleontologists presented a symposium:
W. H. TWENHOFEL, director of the symposium, University of Wisconsin, Madison, Wisconsin

The Different Fields of Geology as Aids to the Discovery of Petroleum

1. RAYMOND SIDWELL, Texas Technological College, Lubbock, Texas
Sedimentary Petrology
2. JOHN EMERY ADAMS, Standard Oil Company of Texas, Carlsbad, New Mexico
Paleogeography
3. H. B. STENZEL, University of Texas, Bureau of Economic Geology, Austin, Texas
Stratigraphy
4. H. V. HOWE, University of Louisiana, Baton Rouge, Louisiana
Use of Paleontology by the Oil Industry

The geophysicists held a symposium:
Maintaining Geophysical Operations during the War

The special and presidential addresses given before joint sessions are here listed. They are to be published in a later *Bulletin*.

1. F. M. VAN TUYL, C. A. HEILAND, C. F. BARB, J. HARLAN JOHNSON, W. A. WALDSCHMIDT, BEN H. PARKER, DART WANTLAND, W. S. LEVINGS, L. W. LEROY, R. M. TRIPP, and W. W. SKEETERS, Departments of Geology, Geophysics, and Petroleum Engineering, Colorado School of Mines, Golden, Colorado
Review of Petroleum Geology in 1942

Joint technical session of A.A.P.G., S.E.P.M., and S.E.G. during presidential address of F. L. Aurin, April 8, in Crystal Ball Room, Hotel Texas, Fort Worth.

2. F. H. Lahee, Sun Oil Company, Dallas, Texas
   Wildcat Drilling in 1942
3. K. C. Heald, The Gulf Companies, Pittsburgh, Pennsylvania
   World War II and Geology
4. Herschel L. Driver, President, S.E.P.M., Standard Oil Company of California, Los Angeles, California
   Economic Paleontolgoy and Mineralogy—An Appraisal
5. Frank Goldstone, President, S.E.G., Shell Oil Company, Inc., Houston, Texas
   Maintaining an Adequate Level of Geophysical Prospecting
6. F. L. Aurin, President, A.A.P.G., Southland Royalty Company, Fort Worth, Texas
   The Petroleum Geologist and the War
7. Richard J. Gonzalez, Humble Oil and Refining Company, Houston, Texas
   War-Time Changes in the Petroleum Industry
8. E. DeGolyer, Assistant Deputy Petroleum Administrator for War, Washington, D. C.
   Present Status of Petroleum Exploration Problem in the United States
9. L. F. McCollum, President, The Carter Oil Company, Tulsa, Oklahoma
   Some Factors Influencing the Declining Rate of Crude-Oil Discoveries—The Geologist's Responsibility in the Present Situation
10. W. B. Heroy, Director, Division of Reserves, Petroleum Administration for War, Washington, D. C.
    Reserves in Action
11. A. I. Levorsen, consulting geologist, Tulsa, Oklahoma
    Discovery Thinking
12. Claude E. ZoBell, Scripps Institution of Oceanography, La Jolla, California
    Bacteria as Geological Agents, with Particular Reference to Petroleum

A.A.P.G. PAPERS PRESENTED BY TITLE

1. George R. Kribbs, Bankline Oil Company, Los Angeles, California
   Oil Development Activities in California, 1942
2. R. M. Larsen, United States Geological Survey, Casper, Wyoming
   Developments in the Rocky Mountain Region in 1942
3. H. J. Simmons, Jr., Godfrey L. Cabot, Inc., Charleston, West Virginia, and W. H. Young, Jr., Empire Gas and Fuel Company, Wellsville, N. Y.
   Developments in New York in 1942
4. Charles R. Fettke, Carnegie Institute of Technology, Pittsburgh, Pennsylvania, and Parke A. Dickey, Forest Oil Corporation, Bradford, Pennsylvania
   Development in Pennsylvania during 1942
5. J. E. Billingsley, West Virginia Gas Corporation, Charleston, West Virginia, and R. C. Lafferty, Jr., Owens, Libbey-Owens, Charleston, West Virginia
   Developments in West Virginia in 1942
6. D. J. Jones, State Geologist, Lexington, Kentucky, and C. D. Hunter, Kentucky-West Virginia Gas Company, Ashland, Kentucky
   Developments in Eastern Kentucky in 1942
7. Kendall E. Born, State Division of Geology, Nashville, Tennessee
   Developments in Eastern Tennessee in 1942
8. Alfred H. Bell, Illinois State Geological Survey, Urbana, Illinois
   Developments in the Eastern Interior Basin in 1942
9. H. J. Hardenberg, Michigan Geological Survey Division, Lansing, Michigan
   Oil and Gas Developments in Michigan during 1942
10. Edward A. Koester, Darby Petroleum Corporation, Wichita, Kansas
    Developments in North Mid-Continent in 1942
11. Joseph L. Borden, The Pure Oil Company, Tulsa, Oklahoma
    Developments in Oklahoma during 1942
12. Roy T. Hazzard and B. W. Blanpied, Gulf Refining Company, Shreveport, Louisiana
    Developments in South Arkansas and North Louisiana in 1942
13. Mississippi Geological Society,* Jackson, Mississippi
    Development in Southeastern United States in 1942
14. G. J. Smith, Pan American Production Company, Houston, Texas
    Developments in 1942, Gulf Coast of Upper Texas and Louisiana

* This paper prepared by Urban B. Hughes, Consulting Geologist; J. B. Wheeler, Stanolind Oil and Gas Company; and R. Merrill Harris, The Union Sulphur Company, Inc.

Joint technical session of A.A.P.G., S.E.P.M., and S.E.G. during presidential address of F. L. Aurin, April 8, in Crystal Ball Room, Hotel Texas, Fort Worth.

Past-presidents of the Association at 28th annual meeting, Fort Worth, Texas, April, 1943.
Seated, left to right: G. C. Gester (1927); W. B. Heroy (1934); L. C. Snider (1940); J. Elmer Thomas (1917); Alexander Deussen (1918); E. L. DeGolyer (1925).
Standing, left to right: F. L. Aurin (1942); Henry Ley (1939); F. H. Lahee (1932); R. S. McFarland (1928); A. I. Levorsen (1935); H. B. Fuqua (1937); Frank R. Clark (1933).

15. R. M. Trowbridge, Consulting Geologist, Tyler, Texas, and T. J. Burnett, Humble Oil and Refining Company, Tyler, Texas
Developments in East Texas during 1942
16. North Texas Geological Society, Wichita Falls, Texas
Developments in North and West-Central Texas in 1942
17. F. C. Owens, Consulting Geologist, Corpus Christi, Texas, and E. A. Taegel, The Chicago Corporation, Corpus Christi, Texas
Developments in South Texas in 1942
18. Robert I. Dickey, Forest Development Corporation, Midland, Texas, and Bernerd A. Ray, Consulting Geologist, Midland, Texas
Developments in West Texas and Southeastern New Mexico during 1942
19. J. G. Crawford and R. M. Larsen, United States Geological Survey, Casper, Wyoming
Occurrence and Types of Crude Oil in the Rocky Mountain Region
20. Kenneth K. Landes, University of Michigan, Ann Arbor, Michigan
Porter Oil Field, Midland County, Michigan
21. John R. Ball, Northwestern University, Evanston, Illinois, and G. Frederick Warn, United States Army
Lithological and Faunal Variations in the Brassfield Formation
22. Everett Carpenter, Watchorn Oil and Gas Company, Shawnee, Oklahoma
East Watchorn Field, Pawnee County, Oklahoma
23. C. W. Sanders, Shell Oil Company, Inc., Houston, Texas
Stratigraphic Type Oil Fields and Proposed New Classification of Reservoir Rocks
24. Stuart K. Clark, Continental Oil Company, Ponca City, Oklahoma
Classification of Faults
25. F. B. Plummer, H. J. Sawin, H. H. Power, E. E. Merkt, and P. F. Tapp, University of Texas, Austin, Texas
Activity of Certain Micro-organisms in Oil-field Waters and Their Effect on the Flow of Contaminated Water Through Oil-sands

S.E.P.M. PAPERS

1. Parker D. Trask, United States Geological Survey, Washington, D. C.
Problems of Sedimentation in Relation to the Finding of Oil
2. Charles E. Decker, University of Oklahoma, Norman, Oklahoma
The Teaching of Paleontology
3. Alfred Loeblich and Helen Tappan, Tulane University, New Orleans, Louisiana
New Washita Foraminifera
4. Charles E. Decker, University of Oklahoma, Norman, Oklahoma
Cambrian Graptolites of Wisconsin and Minnesota
5. Charles E. Decker, University of Oklahoma, Norman, Oklahoma
Pendent Graptolites of Oklahoma, Arkansas, and Texas

S.E.G. PAPERS

1. Frederick Romberg and Virgil E. Barnes, LaCoste and Romberg, Austin, Texas
The Gravitational Anomaly of the Smoothingiron Granite Mass
2. L. E. Randall, Consultant Geophysicist, Parkersburg, West Virginia
Geophysics in the Appalachian Area
3. A. Garcia Rojas, Petroleros Mexicanos
Geophysical Exploration in Mexico—History and Future Possibilities
4. H. Klaus, Klaus Exploration Company, Lubbock, Texas
Faulting in the Billings Field, Oklahoma, as Interpreted from Torsion Balance Data and from Subsequent Drilling
5. A. E. Lockenvitz, University of Texas, Austin, Texas
The Periodic Variations of the Gravitational Force
6. T. A. Elkins, Gulf Research and Development Company, Pittsburgh, Pennsylvania
Nomograms for Computing Tidal Gravity
7. Joseph L. Adler, Independent Exploration Company, Houston, Texas
Geophysics in Exploration for Stratigraphic Oil Traps
8. R. M. Tripp, Colorado School of Mines, Golden, Colorado
On a Geochemical Survey of the Fort Collins Anticline
9. D. R. Lawrence, Hercules Powder Company, Wilmington, Delaware
Detonation in Explosives
10. Paul Weaver, Gulf Oil Corporation, Houston, Texas
The Geophysicist as a Forecaster

11. AUSTIN N. STANTON and V. N. JAMES, Department of Electrical Engineering, Southern Methodist University, Dallas, Texas
Square Wave Testing of Seismograph Components
12. SYLVAIN J. PIRSON, Petroleum Geologist, Goephysicist and Engineer, State College, Pennsylvania
A Two-Year Summary of Geodynamic Prospecting Results
13. T. R. SHUGART, The Geotechnical Corporation, Dallas, Texas
Frequency Discrimination in the Weathering
14. M. B. WIDESS, Stanolind Oil and Gas Company, Tulsa, Oklahoma
Multiple Branches in Seismic Reflection Time Surface
15. S. S. WEST, Stanolind Oil and Gas Company, Tulsa, Oklahoma
The Analysis of Gases by Scattering of Electrons
16. E. V. MCCOLLUM and ANDREW BROWN, Mott-Smith Corporation, Houston, Texas
Use of the Gravity Meter in Establishment of Gravity Bench Marks
17. J. A. LEGGE, JR., United Geophysical Company, Pasadena, Claifornia
Determination of the Elevation Factor by the Method of Least Squares
18. L. L. NETTLETON and T. A. ELKINS, Gulf Research and Development Company, Pittsburgh, Pennsylvania
Association of Magnetic and Density Contrasts with Igneous Rock Classifications
19. W. L. RUSSELL, Well Surveys, Inc., Tulsa, Oklahoma
The Radioactivity of Sedimentary Rocks
20. JOHN J. RUPNIK and J. A. LEGGE, JR., United Geophysical Company, Pasadena, California
The Determination of the Velocity Function $V=V_0+az$ *for Any Given Set of Time-Depth Data by Means of the Method of Least Squares*
21. E. D. ALCOCK, National Geophysical Company, Dallas, Texas
The Selection of Computational Methods for Seismic Paths
22. S. S. WEST, Stanolind Oil and Gas Company, Tulsa, Oklahoma
On the Mutual Impedance of Collinear Grounded Wires
23. JOSEPH L. ADLER, Independent Exploration Company, Houston, Texas
Refinement of Simplified Corrections for Grzavity-Meter Surveys
24. MARTIN J. GOULD, United States Navy Department, Bureau of Ships, Washington, D. C.
(1) *Analysis of Various Proposed Explanations of the Ground Roll*
(2) *Note on Relation of Ground Roll from Explosion to Ground Roll from Ground Shaker*
25. W. B. AGOCS, Department of Physics, Lehigh University, Bethlehem, Pennsylvania
A Method of Determining the Time Break on Deep Sea Records from the Water Sound Arrivals
26. C. W. HORTON, University of Houston, Houston, Texas
Secondary Impetuses in a Well Velocity Survey
27. WILBUR H. YOUNG, JR., Empire Gas and Fuel Company, Wellsville, New York
Results of a Detailed Reflection Profile in New York
28. CHARLES W. OLIPHANT, Radio Research Laboratory, Harvard University, Cambridge, Massachusetts
Geochemical Data of the Lamont Prospect, Grant County, Oklahoma
29. REV. DANIEL LINEHAN, S.J., Weston College, Weston, Massachusetts
Seismic Surveying in New England as an Aid to Geologic Interpretation
30. ALFRED WOLF, Geophysical Research Corporation, Tulsa, Oklahoma
The Motion of a Weight on the Surface of an Elastic Earth

MINUTES, TWENTY-EIGHTH ANNUAL BUSINESS MEETING HOTEL TEXAS, FORT WORTH, TEXAS APRIL 8–9, 1943

FRITZ L. AURIN, *presiding*

The meeting was called to order at 9:30 A.M., April 8, 1943, by Fritz L. Aurin, president.

1. *Ballot committee.*—The president appointed a ballot committee, composed of S. A. Thompson, C. D. Speed, Jr., and R. K. DeFord, chairman.

2. *Resolutions committee.*—The president appointed a resolutions committee composed of F. A. Morgan, K. C. Heald, Carey Croneis, and Paul H. Price, chairman.

3. *Nomination of officers.*—The president called for nomination of officers of the Association for the ensuing year. The following nominations were made.

For president: A. RODGER DENISON, nominated by O. L. Brace

For vice-president: ROBERT W. CLARK, nominated by Ira H. Cram

For secretary-treasurer: ROBERT E. RETTGER, nominated by C. H. Row

For editor: CAREY CRONEIS, nominated by C. D. Speed, Jr.

The meeting recessed until 4:00 P.M., April 9.

The recessed meeting was called to order by Fritz L. Aurin, presiding, and E. O. Markham, acting as secretary.

4. *Reading of minutes.*—It was moved, seconded, and carried that the minutes of the annual meeting held at Denver, Colorado, April 22–24, 1942, be not read since they have been published in the *Bulletin*.

5. *Election of officers.*—It was moved, seconded, and carried that the unanimous election of the following officers be recorded.

President: A. RODGER DENISON

Vice-president: ROBERT W. CLARK

Secretary-treasurer: ROBERT E. RETTGER

Editor: CAREY CRONEIS

6. *Report of officers.*—The reports of president Aurin and secretary-treasurer Markham were read (Exhibits I and II).

7. *Report of resolutions committee.*—The report of the resolutions committee was read by Paul H. Price (Exhibit IV).

8. *Report of business committee.*—The report of the business committee was read by Robert W. Clark. It was moved, seconded, and carried that the report be adopted (Exhibit V).

[The following reports appear as exhibits as part of the minutes.

I. President, Fritz L. Aurin.
II. Secretary-treasurer, Edmond O. Markham.
III. Editor, W. A. Ver Wiebe.
IV. Resolutions, Paul H. Price, chairman.
V. Business, D. Perry Olcott, chairman.
VI. National service, Fritz L. Aurin, chairman.
VII. Distinguished speakers, John L. Ferguson, chairman.
VIII. College curricula in petroleum geology, F. H. Lahee, chairman.
IX. Research, A. I. Levorsen, chairman.
X. National Research Council Division of Geology and Geography, A. I. Levorsen, representative.
XI. Geologic names and correlations, J. G. Bartram, chairman.
XII. Applications of geology, Carey Croneis, chairman.
XIII. Publication, J. V. Howell, chairman.]

9. The twenty-eighth annual meeting adjourned at 5:15 P.M.

FRITZ L. AURIN, *president* EDMOND O. MARKHAM, *secretary*

EXHIBIT I. REPORT OF PRESIDENT

(Year ending April 9, 1943)

INTRODUCTION

On account of war conditions, the past year has been one of the most trying in the history of the Association. Among the many handicaps were the increased responsibilities on all officers, employees, and committees resulting from the additional requirements on their time and work not incident to normal peace times.

Our financial position has improved slightly over that of last year. The total assets at December 31, 1942, were $119,755.91 as compared with $119,183.33 at the same time

in 1941. The increase in market value of investments during 1942 was $2,951.55. The total net income for 1942 was $5,482.27 as compared to $3,166.91 in 1941. Even though the past year may be considered a success from the financial standpoint, there is a possibility that other factors may arise during the coming year necessitating capital expenditures in excess of those during the past year.

The total membership increased from 3,717 as of March 1, 1942, to 3,923 as of the same date in 1943; however, the total as of December 31, 1942, was approximately 4,000.

ACTIVITIES OF ASSOCIATION

All of the normal activities of the Association have continued as in preceding years, but, as stated, some of the committees have had increased responsibilities. You have probably noted that the *Bulletin* is smaller in number of pages, but the amount of printed matter is comparable with that in previous *Bulletins*. The change was accomplished by increasing the length and width of the printed matter on each page and resulted not only in a substantial reduction in cost of printing, but also conformed to the request of the Government agencies for conservation of paper.

The business committee, under the able leadership of D. P. Olcott as chairman, has had a very responsible and serious mission to perform. Many problems have been brought to the attention of this committee and it has used its best judgment in their consideration and recommendations concerning them. It has been many years since this committee has been called upon to make so many decisions on matters directly affecting the welfare of the Association and, indirectly, the affiliated societies and profession in general.

The Association is especially indebted to the distinguished lecture committee for the aggressive and excellent programs that have been carried out this year. The interest by the affiliated geological societies in the speakers and their subjects has been most gratifying. The organization and planning of their programs have clearly demonstrated that the work of this committee has been a great contributing factor in the interest and attendance at the meetings of the affiliated societies. The credit for the valuable work of that committee is largely due to the aggressive leadership of John L. Ferguson as chairman. The scope and activities of this committee should continue to expand so that all affiliated societies can receive the benefits of these planned programs.

The national service committee has had more work and responsibilities than that of any other. The activities this year were a continuation of the policies and program of the preceding year. The work of this committee may be briefly summarized in the following excerpt from the report of the national service committee.

> The national service committee has been accused by a few of trying to place all the petroleum geologists in military service. On the contrary, it was early seen that the outstanding service which we could give to our members was to keep them advised of the changing needs of our Armed Forces and civilian occupations. Therefore, a large part of the efforts of this committee during the past year was given toward the collection and dissemination of all possible information which would aid our members in deciding whether to stay in civilian occupations or enter the Armed Forces. For those who elected to enter the Armed Forces, we have tried to furnish every type of information which would aid them in entering the particular service where their education and experience would be most valuable. We have repeatedly stated on many occasions and have stressed the importance of the fact that serious inroads into exploration personnel would handicap the efficiency and effective work in the discovery of new reserves.

This committee was greatly indebted to the aggressive work of vice-chairman A. R. Denison, K. C. Heald, M. G. Gulley, and Robt. F. Imbt, and the coöperative efforts of all the affiliated geological societies.

The research committee has continued to function as in the past years under the brilliant leadership of A. I. Levorsen. I do not know of any committee in the history of the Association that has contributed so much to the interest and welfare of A.A.P.G. and most of the praise for the success of this committee is due to Mr. Levorsen. It is my understand-

ing that he expects to retire from the chairmanship of this committee and I am absolutely certain that all members of our Association join me in extending to him our thanks for the great work he has done for us with our highest praise thereof.

The other committees have carried on their respective duties as in the past. Even though their work may not have entailed the responsibilities of those already mentioned, they have fulfilled the requirements of their functions in a most satisfactory manner and were willing at all times to do everything possible to coördinate their efforts with other committees and the program of the Association for the benefit of the members.

The executive committee has had plenty of work to do this year. I have had to devote most of my available time to the national service committee and in doing so it became necessary to allocate more responsibilities to other members of that committee. Paul Weaver, E. O. Markham, and W. A. Ver Wiebe have been very active in this respect. I am very grateful to Paul Weaver for the fine coöperation and interest in handling matters normally taken care of by the president. Many programs, projects, and problems have been called to our attention and some have originated within this committee. Even though satisfactory results have not always been obtained, the executive committee has tried to give them serious consideration and investigation. Among some of the many problems have been:

1. Procurement of restricted aerial photographs
2. Courses in interpretation of aerial photographs
3. The seeming lack of interest or understanding on the part of some Government agencies to consider the geologist in the educational and deferment policies
4. Constitutional amendments for election of officers under certain conditions
5. Renewal of charter of incorporation of A.A.P.G.
6. Manpower shortage of geological personnel
7. And many others too numerous to mention.

RECOMMENDATIONS

1. That the work of the national service and distinguished lecture committees be continued and activities expanded.

2. That the close relationship now existing between the affiliated societies and the A.A.P.G. be continued and that this bond become closer than ever before. In the events to come, it will be necessary to have the whole-hearted support and coöperation of all members of A.A.P.G. and especially that of the affiliated societies in support of our programs in personnel problems and the War Effort. The affiliated societies can also stimulate interest in affairs of the Association and the applications of new members and reinstatement of former members to membership in A.A.P.G.

3. All members are urged to do everything possible to encourage and stimulate increased exploratory activities and discoveries so that there will be no question concerning the availability of ample petroleum production for the successful prosecution of the war.

4. All members are urgently requested to sponsor the program of the American Geological Association (or similar title) so that the work of the geologist and the applications of geology to the War Effort and essential industry can be fully understood by the public, Government officials, and the Armed Forces.

CONCLUSIONS

I appreciate the coöperation of all committees, the headquarters office, the membership, and affiliated societies in working for another successful year for the A.A.P.G. It has not been possible for me to visit all of the geological societies on account of the heavy responsibilities of the national service committee and my business connections. I hope that all of you will understand that it was not a matter of not being interested, but that time would not permit.

Again, I appeal to all members to give their full support to the new executive committee and all other committees and, in addition, to make this year the most outstanding one in our history for doing everything possible to coöperate with the War Effort.

F. L. AURIN, *president*

EXHIBIT II. REPORT OF SECRETARY-TREASURER
(Year ending April, 1943)

MEMBERSHIP

The Association has completed its first year under war-time conditions, and in spite of the drain on both manpower and finances through the Nation, a steady growth in the Association's membership continued during 1942 and the first quarter of 1943. This is the eighth consecutive year that the Association has recorded a growth in its membership, and there was a net increase of 206 members, a 5.54 per cent increase, which compares with a 7 per cent increase for the previous year. During the past year, 263 new members and associate members, and 48 reinstatements were added to the Association rolls; and a total membership of 3,923 as of March 1, 1943, constitutes a record high. As of the same date, there were 105 applications on hand, which compared with 110 for the previous year.

Under the amended by-laws, Sec. 2, Art. 1, of 1942, in which the executive committee suspended the annual dues to members or associate members serving in the armed forces, there were, as of March 1, 1943, 79 members accepting deferment. These service men members are not receiving the *Bulletin*, but it is the intention of the Association management to hold a sufficient number of bulletins in the stockrooms to supply the deferred in the post-war period.

The records in the Association headquarters as of March 11, 1943, show a total of 444 members serving in the armed forces of the United States and Allied countries. At the same date, 169 members were employed in governmental services throughout the Allied countries.

During the past year, thirteen of our valued members have passed away, and their loss will be keenly felt by the Association. These are the following.

Honorary—Orcutt, W. W., April 27, 1942
Schuchert, Charles, November 20, 1942
Active— Coryell, Lewis S., September 16, 1942
Eley, Hugh M., May 10, 1942
Gillette, Tracy, November 9, 1942
Johnston, Kenneth A., November 13, 1942
Keeler, William W., January 4, 1943
McGlothlin, William C., June 1, 1942
McKanna, Edwin A., October 9, 1942
Orr, Milo M., September 11, 1942
Associate—Boggs, Frank S., June, 1942
Fanguy, Nolan A., August 22, 1942
Fullerton, Donald Alexander, December 21, 1942

Two well organized committees that were established last year and functioned this year with outstanding success were: the national service committee, which classified and assisted in establishing members seeking war services where they were best fitted; and the lecture committee, which booked and supervised distinguished geological speakers for the several Association affiliated societies.

FINANCES

The annual audit, which was published in the March *Bulletin*, showed the status of Association finances and the operating statement of 1942. Tables IV-X inclusive, furnish additional information and offer a comparison with past years.

E. O. MARKHAM, *secretary-treasurer*

TABLE I

Total Membership by Years

May 19, 1917	94
February 15, 1918	176
March 15, 1919	348
March 18, 1920	543
March 15, 1921	621
March 8, 1922	767
March 20, 1923	901
March 20, 1924	1,080
March 21, 1925	1,253
March 1, 1926	1,504
March 1, 1927	1,670
March 1, 1928	1,952
March 1, 1929	2,126
March 1, 1930	2,292
March 1, 1931	2,562
March 1, 1932	2,558
March 1, 1933	2,336
March 1, 1934	2,043
March 1, 1935	1,973
March 1, 1936	2,169
March 1, 1937	2,331
March 1, 1938	2,646
March 1, 1939	2,951
March 1, 1940	3,240
March 1, 1941	3,474
March 1, 1942	3,717
March 1, 1943	3,923

TABLE II

Comparative Data of Membership

	March 1, 1942		*March 1, 1943*	
Number of honorary members	15		13	
Number of life members	6		7	
Number of members	2,921		3,039	
Number of associates	775		864	
Total number of members and associates		3,717		3,923
Net increase in membership		243		206
Total new members and associates	344		263	
Total reinstatements	31		48	
Total new members and reinstatements		375		311
Applicants elected, dues unpaid	13		17	
Applicants approved for publication	19		41	
Recent applications	78		47	
Total applications on hand		110		105
Applicants for reinstatement elected, dues unpaid	0		0	
Recent applications for reinstatements	2		0	
Total applications for reinstatement on hand		2		0
Applicants approved for transfer, dues unpaid	0		0	
Applicants for transfer approved for publication	3		6	
Recent applications for transfer on hand	5		4	
Total applications for transfer on hand		8		10
Number of members and associates resigned	21		17	
Number of members and associates dropped	93		75	
Number of members and associates died	18		13	
Total loss in membership		132		105
Total gain in membership		375		311
Number of members and associates in arrears, previous years	124		169	
Members in arrears, current year	991		987	
Associates in arrears, current year	283		299	
Total number members and associates in arrears, current year		1,274		1,286
Total number members and associates in good standing		2,319		2,468

TABLE III

GEOGRAPHIC DISTRIBUTION OF MEMBERS

March 1, 1943

Alabama	12	Louisiana	229	Ohio	25
Arizona	3	Maine	1	Oklahoma	517
Arkansas	22	Maryland	7	Oregon	2
California	487	Massachusetts	15	Pennsylvania	78
Colorado	70	Michigan	39	South Carolina	3
Connecticut	6	Minnesota	7	South Dakota	4
Delaware	2	Mississippi	36	Tennessee	15
Dist. of Columbia	73	Missouri	29	Texas	1,208
Florida	19	Montana	16	Utah	5
Georgia	10	Nebraska	12	Vermont	1
Illinois	136	New Hampshire	1	Virginia	17
Indiana	61	New Jersey	18	Washington	11
Iowa	10	New Mexico	25	West Virginia	21
Kansas	161	New York	106	Wisconsin	5
Kentucky	21	North Carolina	6	Wyoming	25
		North Dakota	3		

Total members in United States 3,580

Alberta	31	France	2	Palestine	2
Angola	1	Germany	2	Panama Canal Zone	2
Arabia	2	Haiti	2	Papua	2
Argentina	19	Hawaii	1	Persian Gulf	3
Australia	13	India	2	Peru	6
Austria	1	Iran	1	Philippine Islands	4
Barbados	1	Iraq	2	Portugal	1
Belgian Congo	1	Italy	1	Roumania	2
Bolivia	1	Japan	2	Saskatchewan	1
Brazil	3	Java	2	Scotland	2
Colombia	45	Liban	1	Sumatra	3
Costa Rica	4	Mexico	11	Switzerland	11
Cuba	5	Netherlands	2	Thailand	1
Dominican Republic	3	New Brunswick	2	Trinidad	23
Ecuador	16	New Zealand	9	Turkey	1
Egypt	2	Nicaragua	1	Uruguay	1
England	13	Ontario	6	Venezuela	68

Total members in foreign countries 343
Grand total 3,923

TABLE IV

COMPARISON OF ACCRUED INCOME BY CALENDAR YEARS

	1940	*1941*	*1942*
Dues			
Members	$26,590.00	$28,920.00	$30,270.00
Associates	4,734.00	4,784.00	5,624.00
Total	$31,324.00	$33,704.00	$35,894.00
Bulletin			
Subscriptions	$ 4,420.76	$ 4,650.15	$ 3,937.22
Advertising	7,199.03	8,271.13	8,168.10
Total	$11,619.79	$12,921.28	$12,105.32
Back Numbers, etc.			
Bound Volumes of Bulletin	$ 3,483.10	$ 2,288.00	$ 2,152.90
Back Numbers of Bulletin	2,042.94	895.18	556.99
Other Publications	86.49	113.95	129.94
Total	$ 5,612.53	$ 3,297.13	$ 2,839.83
Special Publications			
Structure Volume II	$ 40.60	$ —	$ —
Geology of Natural Gas*	522.72	336.54	372.60
Geology of Tampico Region*	129.10	173.30	146.35
Index	51.10	15.20	—
Gulf Coast*	462.00	327.20	245.60
Struct. Evol. of Sou. California*	111.44	1.60	—
Map of Sou. California*	24.20	22.31	21.85
Miocene Stratigraphy of California*	340.30	220.00	138.10
Recent Marine Sediments*	2,105.15	710.00	105.10
Stratigraphic Type Oil Fields*	—	1,612.41	3,504.93
Source Beds of Petroleum*	—	779.80	1,746.65
Possible Future Oil Provinces	—	1,165.66	571.23
Origin of Oil	—	309.00	312.00
Permian of W. Tex. & SE. N. Mex	—	—	257.45
Petroleum Discovery Methods	—	—	573.00
Sedimentation	—	—	240.00
Total	$ 3,786.61	$ 5,673.02	$ 8,234.86
Other Income			
Convention Receipts (Net)	$ —	$ 632.84	$ —
Delinquent Dues Charged Off	332.00	333.35	378.00
Interest, General Fund	1,755.79	2,052.97	2,015.16
Interest, Research Fund	83.58	78.27	74.06
Interest, Publication Fund	478.19	509.90	546.06
Profit, sale of Investments, Gen. Fund	177.51	450.00	60.41
Profit, sale of Investments, Publ. Fund	45.00	—	—
Miscellaneous	96.85	136.28	85.83
Sale of Library	55.58	6.00	17.50
Members Reinstated	48.25	97.50	32.50
Adjustment of stated value of Investments to lower of Cost or Market	—	—	2,951.55
Regional Cross Sections	534.55	123.52	27.10
Inventory Increase	—	—	6,227.93
Total	$55,950.23	$60,016.06	$71,490 11

* Income of Publication Fund.

TABLE V

Comparison of Accrued Expenses by Years

General and Administrative Expenses	*1940*	*1941*	*1942*
Salaries—Manager	$ 3,750.00	$ 3,750.00	$ 3,750.00
Clerical	5,831.90	5,770.13	5,104.80
Payroll taxes (including Penalty & Int.)	—	—	4,484.87
Rent	1,500.00	1,600.00	1,620.00
Telephone and Telegraph	366.26	349.61	367.27
Postage	2,036.86	2,116.43	1,812.98
Office Supplies and Expenses	491.71	467.70	394.16
Printing and Stationery	241.78	193.49	405.64
Audit Expense	300.00	300.00	300.00
Insurance and Taxes	237.32	210.14	237.11
Convention Expense (Net)	55.61	—	677.25
Freight and Express	159.93	219.68	229.38
Bad Debts	857.01	776.82	922.50
Miscellaneous	158.76	231.50	332.46
Depreciation—Furn. and Fixtures	209.04	75.75	53.35
Investment Counsel	400.00	400.00	400.00
Traveling Expenses	—	180.40	140.09
Excess of Cost of Investments over lower of Cost or Market	2,500.53	2,352.66	—
Geologic Map of North America[1]	—	1,000.00	—
Bass-Neumann Oil Analysis[1]	811.61	1,025.13	—
Van Tuyl-Parker[1]	—	78.67	—
Tectonic Map of United States[1]	—	75.29	188.71
Whitehead's Radioactivity of Oil & Gas[1]	300.00	—	—
Waldschmidt's Core Analysis[1]	26.22	31.35	—
Revelle-Shepard Oceanography[1]	—	16.22	—
Donation—Soc. of Econ. Paleon. and Min.	—	1,100.00	—
Expense—Dist. Lecture Com.	—	—	500.00
Expense—Natl. Service Com.	—	—	652.26
Total	$20,234.54	$22,320.97	$22,536.83

Publication Expenses	*1940*	*1941*	*1942*
Salaries—Manager	$ 3,750.00	$ 3,750.00	$ 3,750.00
Editorial	3,975.00	3,960.00	4,013.23
Printing Bulletin	17,914.26	18,668.26	17,753.64
Engravings	2,654.54	3,040.69	2,800.37
Separates	377.61	176.07	455.91
Stencils and Mailing	218.23	227.20	252.81
Binding Bulletins	583.79	599.40	578.62
Postage and Express (Bulletins)	1,232.36	1,216.54	977.98
Copyright Fees	24.00	24.00	24.00
Freight, Express, Postage (Other Publ.)	187.88	49.81	188.71
Discounts	52.34	22.90	3.11
Miscellaneous	21.75	100.99	59.75
Special Publications	348.81	1,197.77	12,597.15
Bulletin Inventory Decrease	678.50	290.20	—
Special Publication Inventory Decrease	2,262.40	1,119.02	—
Regional Cross Sections	421.12	85.33	15.73
Total	$34,702.59	$34,528.18	$43,471.01
Total Expense	$54,937.13	$56,849.15	$66,007.84

[1] Research Fund Project.

TABLE VI

Comparison of Net Income by Years

	1940	1941	1942
Accrued Income	$55,950.23	$60,016.06	$71,490.11
Expenses			
General and Administrative	20,234.54	22,320.97	22,536.83
Publication	34,702.59	34,528.18	43,471.01
Total	$54,937.13	$56,849.15	$66,007.84
Excess Income over Expenses	1,013.10	3,166.91	5,482.27

TABLE VII

Investments

	Cost	Market Value End of Year
1940 Values		
General Fund	$62,907.09	$57,418.34
Publication Fund	16,481.17	14,275.03
Research Fund	2,332.72	2,293.97
Total	$81,720.98	$73,987.34
1941 Values		
General Fund	$65,266.95	$57,198.83
Publication Fund	16,569.33	14,698.65
Research Fund	2,411.77	2,264.27
Total	$84,248.05	$74,161.75
1942 Values		
General Fund	$62,272.48	$56,717.53
Publication Fund	16,671.45	15,194.18
Research Fund	2,485.70	2,335.70
Total	$81,429.63	$74,247.41

TABLE VIII

Comparison of Cost of Bulletin

	1940	1941	1942
Total Expenses	$30,146.00	$31,763.11	$30,651.31
Monthly Edition	4,700	4,700	5,000
Total Copies Printed	56,400	56,400	60,000
Total Pages Printed, Including Covers	2,624	2,702	2,315
Total Pages of Text	2,232	2,273	1,893
Total Cost Per Copy	$ 0.535	$ 0.563	$ 0.511

TABLE IX
(Section 1)
SPECIAL PUBLICATIONS

	Geology Natural Gas (1935)	*Geology Tampico Region (1936)*	*Gulf Coast Oil Fields (1936)*	*California Map (1936)*	*Total*
Inventory					
Dec. 31, 1941	$1,756.00	$1,582.39	$ 821.34	$ 41.10	$4,200.83
Dec. 31, 1942	1,472.00	1,493.08	693.23	38.40	3,696.71
Sales	372.60	146.35	245.60	21.85	786.40
Total Edition	2,500	1,575	2,510	940	
Copies on Hand					
Dec. 31, 1941	439	691	468	522	
Dec. 31, 1942	368	652	395	480	
Number of Pages	1,227	280	1,070	—	
Cost (inventory) Per Copy	$ 4.00	$ 2.29	$ 1.755	$ 0.08	
Selling Price					
Members and Associates	4.50	3.50	3.00	.50	
Non-Members	6.00	4.50	4.00	.50	

TABLE IX
(Section 2)
SPECIAL PUBLICATIONS

	Miocene Stratigraphy of California (1938)	*Recent Marine Sediments (1939)*	*Strati-graphic Type Oil Fields (1942)*	*Source Beds of Petroleum (1942)*	*Total*
Inventory					
Dec. 31, 1941	$2,075.25	$ 184.80	$ —	$ —	$2,260.05
Dec. 31, 1942	1,955.25	109.20	3,840.74	1,925.70	7,830.89
Sales	138.10	105.10	3,504.93	1,746.65	5,494.78
Total Edition	1,530	1,500	2,526	1,539	
Copies on Hand					
Dec. 31, 1941	819	66	—	—	
Dec. 31, 1942	790	39	1,361	786	
Number of Pages	450	736	902	566	
Cost (inventory) Per Copy	$2.475	$2.80	$2.822	$2.45	
Selling Price					
Members and Associates	4.50	4.00	4.50	3.50	
Non-Members	5.00	5.00	5.50	4.50	

TABLE IX
(Section 3)
SPECIAL PUBLICATIONS

	Origin of Oil (1941)	*Petroleum Discovery Methods (1942)*	*Sedimen-tation (1942)*	*W. Texas N. Mexico Symposium (1942)*	*Possible Future Oil Provinces (1941)*	*Total*
Inventory						
Dec. 31, 1941	$ 80.50	$ —	$ —	$ —	$ 307.88	$ 388.38
Dec. 31, 1942	24.25	507.38	136.59	271.27	111.63	1,051.12
Sales	312.00	573.00	240.00	257.45	571.23	1,953.68
Total Edition	700*	1,500	1,000	521	2,052	
Copies on Hand						
Dec. 31, 1941	156	—	—	—	764	
Dec. 31, 1942	47	729	435	356	277	
Number of Pages	81	164	68	231	154	
Cost (inventory) Per Copy	$0.516	$0.696	$0.314	$0.762	$0.403	
Selling Price						
Members and Associates	1.00	1.00	.50	1.50	1.00	
Non-Members	1.00	1.00	.50	2.00	1.50	

* Two hundred copies printed in second editon, 1942.

TABLE X

BUDGET

	1942	1943 Estimate
REVENUE		
Dues		
Members	$30,270	$30,000
Associates	5,624	5,000
Reinstatements and Delinquents	410	300
	$36,304	$35,300
Bulletin		
Subscriptions	3,937	3,800
Advertising	8,168	7,500
Bound Volumes	2,152	2,000
Back Numbers	556	500
	$14,813	$13,800
Special Publications		
Geology of Natural Gas	372	300
Geology of Tampico Region, Mexico	146	100
Gulf Coast Oil Fields	245	200
Tectonic Map of California	21	20
Miocene Stratigraphy of California	138	125
Recent Marine Sediments	105	60
West Texas Regional Sections	27	25
Stratigraphic Type Oil Fields	3,504	3,500
Source Beds of Petroleum	1,746	1,500
Possible Future Oil Provinces	571	350
Origin of Oil	312	200
Oil-Discovery Methods	573	500
Permian of West Texas and Southeastern New Mexico	257	200
Tectonic Map of United States	—	1,500
Sedimentation	240	300
	8,251	8,880
Other Income		
Investments	2,695	2,500
Convention (Net)	—	—
Miscellaneous	255	250
	2,950	2,750
TOTAL REVENUE	$62,324	$60,730

	1942	1943 Estimate
EXPENSE		
General and Administrative		
Salaries	$8,854	$9,378
Rent	1,600	1,600
Telephone and Telegraph; Postage	2,180	2,200
Audit Expense	300	300
Investment Counsel	400	400
Insurance, Taxes, Back Taxes	4,685	300
Bad Debts	922	900
Convention (Net)	677	700
Office Supplies, Miscellaneous	1,553	1,500
	21,171	17,278

Bulletin Publication		
Salaries	7,763	7,350
Printing	17,753	18,000
Engraving	2,800	2,800
Separates	455	600
Cloth Binding	578	600
Postage and Express	977	1,000
Miscellaneous	626	650
	30,952	31,000
Special Publications		
Sedimentation	313	145
Origin of Oil	155	175
Source Beds of Petroleum	3,753	—
West Texas Regional Sections	15	15
Stratigraphic Type Oil Fields	6,933	—
Oil-Discovery Methods	1,044	—
Tectonic Map of United States	188	5,500
Permian of West Texas and Southeastern New Mexico	396	—
Permian Symposium	—	500
Freight, Express, Postage	188	200
	12,985	6,535
TOTAL EXPENSE	$65,108	$54,813

Exhibit III. Report of Editor

The year 1943 brings to a close the sixth year of service of the present editor. When he took office in April, 1937, he found that a great deal of the work an editor expects to do is done in the Tulsa office by members of the permanent staff. For instance, the preliminary editing and arranging of the material in a manuscript is done by Miss Daisy Heath, who has been translating the rockhound's language into the King's English ever since 1922. The final preparation of the manuscript for the printer in Menasha is done by Joe Hull. The proofreading of the galley proofs and other proofs is also done in the Tulsa office. The principal duty of the editor, therefore, is to assume responsibility for the nature of the material published in the *Bulletin*, and for the scientific accuracy of the material. This responsibility has various angles and aspects. First of all, it becomes necessary to ascertain whether a given manuscript contains real scientific data, or, at least sound deductions from such data. In addition, it is also necessary to secure, if possible, manuscripts which will be interesting and entertaining. Furthermore, there must be a proper balance in the distribution of manuscripts over a given period of time, so that all the varying interests of our members are properly satisfied. Not all our members are solely interested in structural problems or in stratigraphy. Some members like articles on lithology, areal geology, third dimensional geology, criteria of oil accumulation and of oil origin. Many are interested in specialities such as the chemistry of waters which occur in rock strata, drilling techniques, per-acre recovery, paleontologic phases of oil-well correlation, to mention only a few. Therefore, in order to secure the diversification necessary to satisfy all these interests, the editor must reach out for certain types of papers and encourage competent authors to write manuscripts. This is probably one of the most valuable phases of the editor's work.

When the preceding editor wrote his final report, he pointed out that a definite scarcity of papers existed, and strongly urged that something be done to increase the volume of presentable material. The situation was of such a critical nature that retiring president Reed devoted over half of his address to this topic. He reached the conclusion that the most satisfactory solution of the problem lay in the organization of a special committee

to solicit papers from members. Thus it came about that the committee for publication was appointed early in the year 1937 under the able chairmanship of Fred Lahee, a former editor. When this committee began its work the number of papers on hand was not enough to fill two monthly issues of the *Bulletin*. In view of the fact that approximately 2 months is needed for preparing a paper properly for the printer and for having the author inspect his galley proofs, such a backlog must be considered an absolute minimum. The committee evidently went to work promptly, for within 2 years a more favorable backlog had been built up. Within 4 years the situation was so improved that approximately a 6-months supply of papers was on hand. At the present moment the number of papers awaiting publication is enough to supply perhaps 10 monthly *Bulletins*. In the opinion of the editor, this amount is the optimum quantity to have on hand. A larger amount of material on hand for publication means that some authors must wait unduly long before they see their work in print. A smaller backlog means that the editor is unable to secure a desirable diversification in published material.

The responsibility of sifting the value of the papers submitted for publication devolves upon the editor. However, here again, he has abundant and capable help from associate editors. The associate editors are all men who have become specialists in the geology of a given geographic area or within a given field of geologic knowledge. The present editor wishes to state that he has always received excellent advice from the members of the associate editor group. In addition to the group just mentioned, there are in the ranks of our membership specialists on certain phases of geologic research. These men have been called upon whenever a manuscript arrived which required critical evaluation by a specialist. Occasionally, it has been found necessary to go outside the ranks of our membership in order to secure the advice necessary before publication.

Another aspect of this situation which should not be overlooked is the unique system of screening a paper which has been developed by our Association. In this system the prospective author is encouraged to present his paper orally before one or more local geological societies. The result has been that many an author was spared the embarrassment of having erroneous statements printed under his name. The system has also spared the editor the unenviable duty of rejecting some papers. Probably this accounts for the fact that the number of papers rejected rarely exceeds 10 per cent of the total number submitted within a given interval of time.

One of the matters to which the editor devoted considerable time and attention is the matter of reproducing photographs. Prior to 1940, it was customary to use the half-tone method of reproducing photographs, and the plates which appeared in our *Bulletin* were made with a 120-mesh screen. In general, such a screen is fine enough to eliminate much of the graininess which might conceivably spoil even a very good original photograph. Nevertheless, it is possible to secure much greater fidelity with a finer-mesh screen, especially when the printing is done on a glossy and rather heavy-weight paper. Such a paper with a fine-mesh screen was used in the illustrations appearing on pages 216 to 225 of the February number of the 1941 *Bulletin*. In this instance, a 150-mesh screen was used for half-tone reproduction. If the complete elimination of graininess is desired then it becomes necessary to use the full-tone or "collotype" process. This method is used for all photographs by the Geological Society of America in their *Bulletin*. On such a reproduction one may use a hand lens at magnifications up to 10 diameters and perceive the detail exactly as photographed. The advantage of such magnification is especially apparent in photographs of fossils or of photomicrographs. Naturally, this method is more expensive than the half-tone method for several reasons. One reason is that the plates have to be glued in by hand after they have been prepared. For an example of this type of illustration our members can consult the plates contained between pages 64 and 65 in the January number of Volume 26 (1942). It is hoped that each member will examine these reproductions carefully and write his

opinion to the editor, so that he may be guided by their wishes in planning future editions of the *Bulletin.*

Geologic notes.—Another detail to which the editor has devoted a great deal of time is the matter of increasing the contributions which come under the heading of "Geologic Notes." By the method of conducting a sample poll among members at each annual convention, the editor early came to realize that the headings entitled "At Home and Abroad" and the "Geologic Notes" were more popular than the longer major articles. The tendency seems to be to "save" the major articles for an emergency for reference reading, but to "enjoy" the shorter articles currently. An effort was therefore made to solicit shorter contributions by writing to numerous individuals who had information of the type needed. As might be expected the response did not measure up to the effort expended. Nevertheless, this approach is definitely worth while and should be continued by future editors.

Below is a list of topics which may furnish our readers with a clue to the great variety of geological phenomena that might be made into a geologic note. It is presented in the hope that each member will read it and then send in promptly some item of local interest, so that other members in more remote districts may also enjoy the benefit of it. The items which fall into the list of possibilities are as follows: unusual sequence of rocks in otherwise well known area; nature and composition of basement rocks reached in drilling; unique producing horizon such as basalt, serpentine, or even shale; sinkholes and ravines in buried limestone terranes; exceptional porosity conditions such as to absorb remarkable quantities of salt water in disposal wells; freak wells which flow freely for a short time and then stop flowing; wells which respond to the flow of other near-by wells in their behavior; exceptional gravity of oil, either high or low; abnormal pressure conditions in oil or gas pools; unusual temperature gradient; evidence regarding the throw or hade of a fault underground; new salt dome; results of directional drilling, such as drilling a number of wells from one surface location; reasons for success or failure of electric well-log correlation in certain restricted areas; wells which produce unusual gases with or without oil; record of well in fairly remote or partly explored area; accurate description of seepages. A perusal of this list will bring to the mind of experienced geologists cases in which new oil discoveries were made on the basis of a "straw in the wind." One such idea may have helped to suggest where to prospect or how to proceed in locating a likely oil-bearing area. Considering how vital it is for us to concentrate on finding new oil supplies at the moment, every such hint will be appreciated by the younger members of our profession.

New bibliography.—The Association has published 26 volumes of the *Bulletin* and is well started on the 27th volume. In recent years the number of pages in each volume has averaged well over 1,500 pages of information on various aspects of petroleum geology. Such a large volume of information is the foundation of research work and therefore deserves an index. As oil becomes increasingly more difficult to find and our members are sent to new areas to find it, they need to know quickly what has been published on the new area. It is, therefore, high time that a comprehensive bibliography be prepared. For the purpose no better model could be found than the one issued every two years by the United States Geological Survey. In this bibliography the first half consists of a list of all articles published and these are arranged alphabetically by authors. Where one author has written more than one article a reference number is appended so that the exact title may be found quickly. The second half of the bibliography is the Index which is so arranged that any bit of information contained in the various articles may be found under a number of different key words. Naturally, the compilation of such a bibliography will require much time and labor and the Association should not expect the already overworked staff at headquarters to undertake the task. The need for this bibliography has been brought to the attention of the editor by various members at various times and he believes that no special publication would be more eminently worth while at this particular moment.

Statistical data.—In the tables below are summarized the comparative statistical data for the six year span from 1937 to 1943.

TABLE I

COST OF BULLETIN

	1937	1938	1939	1940	1941	1942
Expenses in round numbers	$21,600	23,930	26,650	30,150	31,760	30,650
Monthly total	3,500	3,900	4,400	4,700	4,700	5,000
Pages	2,061	2,174	2,374	2,624	2,702	2,315
Each *Bulletin* cost	0.515	0.512	0.505	0.535	0.563	0.511
Number of articles	83	92	108	112	119	72

An examination of Table I presented herewith will reveal that the cost of the *Bulletin* has risen from $21,600 in 1937 (January to December) to $31,760 in 1941. The increase is partly accounted for by the number of copies printed which rose from 3,500 per month in 1937 to 5,000 per month in 1942. Part of the increase is due also to the slightly higher cost of paper and of printing. The cost of each number of the *Bulletin* has remained fairly stationary at slightly more than 50 cents per copy. The number of pages of material rose from 1937 to 1941, but shows a decided drop in 1942. This reduction is primarily due to the desire on the part of the executive committee to exercise caution for the duration of the war. In other words, it is possible that our gross income may shrink and, therefore, it is desirable to curtail expenses before the impact of reduced income makes itself felt. The other reason for the reduced number of pages lies in the change to the new format of the printed page which went into effect with the July issue of the year 1942. A close comparison of the June and the July issues will reveal that the printed lines in the July issue are slightly longer and that there is one more line on each page. The number of words printed on a page of the June issue is somewhat over 500, while the number of words on a page of the July issue is about 600. Thus the difference is considerable and means that 100 pages at present portrays as much information as was formerly contained on 120 pages. Incidentally, the critical observer will also note that a thinner or lighter weight paper is now being used. The difference in opaqueness of the two grades of paper is slight, but apparent.

TABLE II

SOURCE OF BULLETIN PAPERS

Year	*Total Number*	*Convention Programs*	*Spontaneous Origin*	*Oil-Company Men*	*Consulting Geologists*	*Others**
1937	83	34	39	45	14	25
1938	92	49	27	41	16	34
1939	108	48	28	53	15	40
1940	112	44	35	53	22	37
1941	119	56	44	47	19	53
1942	72	30	42	28	13	31

* Others includes teachers, students at universities, State Geological Survey geologists and Federal Survey geologists.

An examination of Table II reveals that between 40 per cent and 50 per cent of our papers are first presented at the time of our annual convention. The table also shows that about half of our published papers originate in the offices of the major oil companies. There appears to be a decline in the number of contributions by oil-company geologists during the last two years.

TABLE III

GEOGRAPHIC DISTRIBUTION OF MAJOR ARTICLES AND NOTES

California	9	Kansas	2
Texas West	7	West Virginia	2
Texas South	5	Nebraska	2
Texas North	3	Indiana	2
New Mexico	3		
Montana	3	One article for each of the following:	
Arkansas	3	Oklahoma, Michigan, Colorado, New York,	
Illinois	3	Ohio, Kentucky, Dakotas, Australia, Canada	
Louisiana	2		

W. A. VER WIEBE, *editor*

EXHIBIT IV. REPORT OF RESOLUTIONS COMMITTEE

Be it resolved that we, in behalf of the members of the American Association of Petroleum Geologists and associated societies of Economic Paleontologists and Mineralogists and of Exploration Geophysicists, express our sincere appreciation to the convention committees, and especially the members of the Fort Worth Geological Society, who have been instrumental in the smooth operation of this very successful convention at this critical time in our Nation's history.

We wish to strongly commend the collective thought which has been responsible for directing the program into the channels of definite objectiveness as follows:

1. The development and improvement of methods of exploration and their more intense application to petroleum discoveries;
2. The furtherance and support of the work undertaken by the research committee;
3. The accomplishments of the committee arranging the program of distinguished lectures;
4. The expansion of the program for stimulating public interest in geology toward the realization that its diverse applications permeate our every-day existence.

We further wish to commend the efforts of the following:

1. The excellent manner in which those responsible for the press relations handled the news coverage;
2. Walter A. Ver Wiebe for his long and excellent service as editor of the *Bulletin*;
3. The executive committee, collectively and individually, for devoted direction of the activities of the Association;
4. J. P. D. Hull and each of his assistants for the continued successful handling of the business of the Association;
5. The several geological societies, individuals and State geological surveys, for their educational exhibits;
6. The commercial service companies for the efficient assistance in registration and bulletin-board service;
7. The Texas Hotel, its convention staff, all hotels of Fort Worth, and especially those residents of the city who opened their homes to the members of our Association.

We commend the media whereby the Association recognized the military status of our members in the armed services, and express regret at their absence.

PAUL H. PRICE, *chairman*
CAREY CRONEIS
K. C. HEALD
J. B. LOVEJOY
FRANK A. MORGAN

Exhibit V. Report of Business Committee

We recommend as follows.

1. That you approve and commend the work of the committee on college curricula in petroleum geology, the national service committee, and the distinguished lecture committee, and recommend to the executive committee that their work be continued for another year.

2. That you approve and recommend to the executive committee an increase in the revolving fund for the distinguished lecture committee from $500 to $1,000.

3. That the reports of the standing and special committees be approved and published in the *Bulletin.*

4. That the following resolution be adopted.

Be it resolved, by the voting members of the American Association of Petroleum Geologists, duly assembled at the annual meeting held in the City of Fort Worth, County of Tarrant, and State of Texas, on the 9th day of April, 1943, that the members of the executive committee of the American Association of Petroleum Geologists be, and they are hereby, authorized to make application to the Secretary of State of the State of Colorado, for renewal and extension of the certificate of incorporation of the American Association of Petroleum Geologists, and are also authorized to take any additional steps in connection therewith that the executive committee deems necessary, for a period of twenty years from April 21, 1944, and to pay the expenses of such renewal and extension out of the funds now on hand belonging to said Association.

5. That the following resolution be adopted and referred to the executive committee.

Resolved that the Corpus Christi Geological Society and the New Orleans Geological Society be included among the affiliated societies of the A.A.P.G.

6. That the following amendments to the by-laws be adopted.

Amend Article VI, Section 1, so as to add, at the end of the first paragraph—"and medal award committee."

Amend the second paragraph of Section 1, which starts—"The president shall appoint . . . " to read as follows: "The president shall appoint all standing committees except the business committee and the medal award committee, for which provisions are hereafter made."

Add a new section (Number 11) to Article VI which shall be as follows.

"Section 11—The purpose of the committee shall be to choose recipients for all medals or other awards which may be established by the executive committee.

"The committee shall consist of nine members and three ex-officio members. The nine members of the original committee shall be appointed by the president, three of whom shall serve for three years, three for two years, and three for one year. One of each of the groups appointed for the different lengths of time shall be a former president of the Association. Each incoming president shall thereafter appoint three members of the committee to serve for three years, one of which shall be a former president of the Association. Vacancies on the committee due to resignation or other causes shall be immediately filled by the president. The ex-officio members shall be: (1) the president of the Association, (2) the president of the Society of Exploration Geophysicists, (3) the president of the Society of Economic Paleontologists and Mineralogists. The president of the Association shall be chairman of the committee unless he shall, at his election, name a chairman to serve for one year."

7. That the sum of $1,500 be granted the Society of Economic Paleontologists and Mineralogists for the year 1943.

D. Perry Olcott, *chairman*

EXHIBIT VI. REPORT OF THE NATIONAL SERVICE COMMITTEE

GENERAL STATEMENT

The national service committee was created in April, 1941. The purpose, scope, and activities of the committee during the first year were outlined and set out in the report presented at the Denver meeting. In order to bring you up to date on the activities of this committee during the past year, the following information is presented.

PROGRESS OF WORK OF THE NATIONAL SERVICE COMMITTEE

After the Denver meeting, an attempt was made by the president to select a suitable chairman of this committee, but the ones he had in mind who were located in strategic positions and who were thought to be well qualified to take charge of the program were not available on account of the heavy burdens of their business connections; therefore, the president has assumed the chairmanship of this committee, not because he wanted more responsibilities, but on account of his having the responsibility of carrying out the program of the previous year and his familiarity with the many problems confronting us during the coming year.

The following members of the A.A.P.G. were appointed on this committee: A. R. Denison, vice-chairman; K. C. Heald, M. G. Gulley, A. E. Brainerd, Ronald K. DeFord, Robert F. Imbt, Ira H. Cram, Eugene Holman, J. R. Lockett, Phil F. Martyn, Frank A. Morgan, Edgar W. Owen, George D. Putnam, Carleton D. Speed, Jr., William H. Spice, Jr., B. B. Weatherby, and W. E. Wrather. The heavy work revolved around the chairman and A. R. Denison, K. C. Heald, M. G. Gulley and Robert F. Imbt. The chairman wishes to take this opportunity of thanking each one of these men for their splendid cooperation and untiring efforts to do everything possible under the circumstances to carry out our program to a successful conclusion. The chairman has made three trips to Washington and K. C. Heald and M. G. Gulley have made many trips to the Capital. Even though our efforts have not been crowned with success in every case, the efforts put forth by Heald and Gulley deserve the highest praise. A. R. Denison made a thorough study of the Selective Service regulations and has passed this information on to the membership. His sound advice and valuable work have been contributed freely at all times and, in addition to that, he has an excellent working knowledge of the work of this committee. Robert F. Imbt and others in the Fort Worth Geological Society contributed much assistance in the compilation and cataloging of information on personnel. The other members of the committee have done excellent work in offering suggestions and disseminating the information sent out in the Memoranda of the National Service Committee and in cooperating with the military or war-effort committees of the affiliated geological societies.

One of the first efforts of the committee after the Denver meeting was the solicitation of cooperation between the geological societies and the commanders of the different Corps area. Many of the societies offered their services in furnishing information on such items as roads, highways, construction material, water supplies, terrain, topography, and location of fuel supplies in their respective areas. The work of the Houston, East Texas, West Texas, South Texas, and Appalachian geological societies are notable examples. Others have offered their services, but from information at hand, no requests have been made for them. There is still a possibility that the geological societies may be called upon for this and additional assistance. There is no question in our minds that the military authorities would find in the affiliated geological societies an excellent source of valuable information and services, in addition to that furnished by the State and Government agencies. These societies are also urged to cooperate fully with these agencies in working out any of their problems relating to the War Effort.

You would be interested in knowing the form and revised results of our tabulation or inventory of the questionnaires. Our master sheets include the following information on

each individual by districts: Qualifications and experience for Topography; Water Supply; Geophysics; Engineering training; Administrative experience; Photo-Geology; Foreign experience; knowledge of Foreign Languages; experience in all phases of Petroleum Geology, Geophysics, Engineering and associated or affiliated subjects; and all the miscellaneous experiences such as Cartography, Photography, Meteorology, Chemistry, Physics, Radio, and Teaching. Some very interesting facts were brought out in this tabulation, as shown in the following table.

ESTIMATED NUMBER OF MEMBERS OF A.A.P.G. SKILLED IN VARIOUS TECHNICAL BRANCHES MOST OF WHICH ARE APPLICABLE TO MILITARY OPERATIONS, AS COMPILED FROM QUESTIONNAIRES

Total questionnaires returned—2,950 out of 3,600 mailed.

Qualified or Experienced for Type of Work	*Estimated for 2,950*	*Estimated for 3,600 on Basis of Proportion for 2,950*
Topography	1,334	1,627
Water supply	765	933
Geophysical (total)	562	685
Seismograph Interpretation	156	190
Seismograph Technical	347	423
Other Geophysical	220	268
Interpretation of aerial photos	1,156	1,410
Engineering	976	1,191
Foreign experience	806	947

Those listed for topography and water supply have either had the necessary college training, or, as in many cases, have had actual experience in these types of work.

Under Seismograph Geophysical would be included those having experience in geological interpretation and the technical phases of this work such as computer, observer, party chief, supervisor, administrative, and research. Other geophysical includes experience with gravity meter, torsion balance, magnetometer, and electrical instruments.

The estimate on those experienced in the interpretation of aerial photographs is conservative, because many who did not have this experience at the time the questionnaires were sent in, have taken the courses on that subject at a later date.

Included in Engineering are those who have had 1–4 years of Engineering in college or experience. The branches of Engineering considered are Petroleum, Production, Mining, Civil, Mechanical, Electrical, Chemical, and Highway.

Foreign experience includes those who have been in work outside of the continental United States for a period of 6 months or longer. There is hardly a country in the world where American petroleum geologists have not carried on exploration field work. Some of these individuals have had experience in as many as twenty foreign countries.

The national service committee has attempted to keep the membership informed on the progress of its work such as: developments in the requests for personnel; frequent changes of rules and regulations governing qualifications for military service and selective service; possibilities for geologists in many branches of military service, and as civilians in essential industry and governmental agencies directly related to the War Effort. In addition to all of these, there has been a very large volume of correspondence, not only with members of the A.A.P.G., but also non-members, concerning information and suggestions on everything outlined. Most of the Memoranda of the National Service Committee have been published in the *Bulletin;* however, a few confidential ones have been distributed to members of that committee only, but even in these cases practically all of that information was disclosed to the local geological societies through members of the committee. Most of the members of the A.A.P.G. have read these memoranda and no attempt will be made to review them except in a general way.

Prior to the Denver meeting last year, the cooperative efforts of the national service committee and war-effort committee of the Geological Society of America made excellent

progress in interesting the military authorities in geologists, but this condition later changed after the rapid expansion of the Armed Forces began to take place. It seemed that we were lost in the shuffle, so to speak; however, the active members of our committee continued to work harder than ever. Officers from Lieutenants to Generals in many branches of the Armed Forces were contacted and the membership has been informed concerning most of these. Our objective in the whole matter was to interest the military forces in the effective and efficient use of the training, experience, and skills of our profession in military operations, rather than to have them scattered through the various branches of service in capacities where their talents could not be utilized. Some of the branches of service contacted on many occasions included the Corps of Engineers, Army Air Corps, Army Specialist Corps, Service of Supply, Armored Force, Army Military Intelligence, and several other branches of the Army; Naval Aviation and Intelligence, the Marine Corps; and the National Roster of Scientific and Specialized Personnel. Our best results were obtained from the Army Air Corps and we are continuing to receive the greatest assistance from that branch.

A.A.P.G. MEMBERS IN ARMED FORCES

It may be of interest to give you the following information on the classification of members of A.A.P.G. in the Armed Forces of the United States and Allied Nations.

CLASSIFICATION OF A.A.P.G. MEMBERS IN ARMED FORCES OF THE UNITED STATES AND ALLIED NATIONS, FEBRUARY 1, 1943

	Privates Cadets Non-Com. Officers Misc.	*Lieuts.*	*Capts.*	*Majors*	*Lieut. Colonels*	*Total*
Army Air Corps	38	59	25	8	2	132
Infantry	26	23	2	3	1	55
Corps of Engineers	14	19	4	5	1	43
Field and Coast Artillery and Anti-Tank	7	27	7	1		42
Armored Force	2	3				5
Signal Corps	3	2				5
Miscellaneous: Military Police, Ordnance, Quartermaster Corps, Military Intelligence	11	10	2	2	1	26
Total Army	101	143	40	19	5	308
Marine Corps	3	5	2			10
Navy	*Misc.*	*Ensigns*	*Lieuts.*	*Lieut. Com.*	*Capts.*	*Total*
Naval Aviation	13	55	38	4	1	111
Coast Guard	1		3			4
Total Armed Forces						423

Figures include only those members about whom we have actual information or records, but do not include many members and non-member geologists who have not notified us of entering military service.

In checking over this table, you will note many interesting items. For example, the Army Air Corps and the Navy are the two most popular branches of service. The total number in the Army Air Corps amounts to 132 as compared with 111 in the Navy. The total number in the Army amounts to 308 and 207 of these are commissioned officers ranking from Lieutenants to Lieutenant Colonels, while the privates, cadets and non-commissioned officers amount to 101, or a ratio of 2:1 in favor of the commissioned officers. The total number in the Navy, not including the Coast Guard or Marines, is 111 and of this number 98, or practically all, are commissioned officers.

In making an analysis of the distribution of the members of the A.A.P.G. in the Armed Forces, we are sure the membership will be interested in a few generalized comments, especially in regard to the question of whether the geologists are in positions where their training and experience as geologists are being utilized. In considering the over-all picture in the Armed Forces, the answer is No, but, of course, there are some outstanding examples of a partial use of such training and experience, and in some instances a broad utilization of geologists *as geologists*. No attempt will be made in this report to explain or give more detailed information on these conditions as they are covered in the paper by K. C. Heald on "World War II and the Geologist." However, in the way of a few comments, it is significant that the Army Air Corps has been the most interested branch of the service in the training and experience of the geologist. We would estimate that at least 75 per cent of the geologists in that branch are being used for the interpretation of aerial photographs and as Photo-Intelligence officers, and placement in the new division known as the Arctic, Desert, and Tropic Information Center. It is also our understanding that Naval Aviation and the Marines are using some of our geologists in capacities similar to those in the Photo-Intelligence of the Army Air Corps. To the best of our knowledge, the Corps of Engineers, Coast Artillery, Armored Force, Military Intelligence, and other branches of service have utilized the geologist *as a geologist* only in limited numbers, and it is in these branches of service where his technical skill can be the most effective. In spite of all this, we have, in our opinion, reached the turning point and these latter branches of service are now beginning to show much more interest in our skills. As evidence of this, we are receiving requests for personnel. It is our hope that most of these requests can be filled from those now in the Armed Forces, as many of the geologists are now serving in capacities where their technical skills are not being utilized. In concluding this part of the report, we should like to state that the national service committee has not attempted to use any political or congressional influence to carry out its program. We have presented our case on its merits to the military personnel concerned.

MEMBERS OF A.A.P.G. IN CIVILIAN CAPACITIES WITH GOVERNMENT IN WAR EFFORT

Many members of the A.A.P.G. are serving in civilian capacities with the Government in the War Effort. They are working with the United States Geological Survey, the Board of Economic Warfare, and the Bureau of Mines in the search for strategic minerals and other important projects. This is one of the most important phases of geological work carried on by the Government agencies; and such work is not only in active operation, but is also expanding rapidly. In addition to the work on strategic minerals, many of our members are doing geological engineering work such as investigating water supplies and advisory services in construction work in connection with military and defense projects. The Office of Petroleum Administration for War is doing extremely important work in connection with many phases of the War Effort and our membership is well represented in positions of responsibility. All of these branches of the Government service are cooperating with both military and civilian requirements.

MANPOWER PROBLEMS OF PETROLEUM GEOLOGISTS

Our latest estimate, February 20, 1943, shows some interesting information in regard to members of A.A.P.G. and non-member petroleum geologists in the Armed Forces and in civilian capacities with Government agencies connected directly or indirectly with the War Effort.

A.A.P.G. members in military service	500
Petroleum geologists (Non-members A.A.P.G. in military service)	100
A.A.P.G. members in civilian capacities with Government and Allied Nations	175

There is a total of 775 in military and civilian capacities with the Government and Allied Nations.

The foregoing estimates do not take into consideration many members of A.A.P.G. who are working for State geological surveys and in work mostly connected with the War Effort. These estimates do not take into account many geophysicists who are not members of the A.A.P.G., but who have been engaged in exploration activities in the petroleum industry, and are now in the Armed Forces or serving in civilian capacities with the Government. Also not included are the many petroleum geologists who are giving a large part of their time in work for the Office of Petroleum Administration for War on committees entitled "Reserves" and "Exploration" and others who are being consulted or acting in an advisory capacity with all Government and State agencies. The total number of petroleum geologists (775) as outlined in the preceding tabulation is a very conservative estimate and, as a matter of fact, if we had complete records on all and took into consideration the time devoted by civilian geologists on war problems of the petroleum industry, this estimate would be increased very substantially.

The approximate number of members in the A.A.P.G. as of December 31, 1942, was 4,000, but this figure also includes those engaged in foreign work and foreign geologists. Normally, there are about 3,500 petroleum geologists in the United States. Even considering a figure of 4,000, then 20–35 per cent of the normal personnel available for petroleum geology are in military service or civilian capacities with or in cooperation with the Government, *so that a shortage of manpower in geological and geophysical work in development and exploration work in the petroleum industry has developed.* The critical need for new petroleum reserves to replace the declining proved reserves and to meet the war-time requirements of the military, civilian, and war industries is a well known fact, as has been reported many times by the Office of Petroleum Administration for War and many other well informed organizations. As petroleum and its products are absolutely vital for the successful prosecution of the war, it will be necessary to safeguard the availability of ample supplies by the discovery and development of new reserves. For more details on this subject, you are referred to the recent statements of Harold L. Ickes, E. DeGolyer, W. B. Heroy, and many others. The work of the petroleum geologist and geophysicist is very important in this program and the responsibility for results is largely theirs. As previously outlined, there is a definite shortage in the personnel requirements of the geological departments of the industry. *A critical situation has developed whereby the industry can not give up many more petroleum geologists and geophysicists without seriously handicapping the necessary exploration program.*

CONCLUSION

The national service committee has been accused by a few of trying to place all the petroleum geologists in military service. On the contrary, it was early seen that the outstanding service which we could give to our members was to keep them advised of the changing needs of our armed forces and civilian occupations. Therefore, a large part of the efforts of this committee during the past year was given toward the collection and dissemination of all possible information which would aid our members in deciding whether to stay in civilian occupations or enter the armed forces. For those who elected to enter the armed forces we have tried to furnish every type of information which would aid them in entering the particular service where their education and experience would be most valuable. We have repeatedly stated on many occasions and have stressed the importance of the fact that serious inroads into exploration personnel would handicap the efficiency and effective work in the discovery of new reserves. We recognized this situation at an early date, so that our first efforts were directed in presenting our case, both military and technical, to the National Roster of Scientific and Specialized Personnel. At a later date one of the members of our committee contacted the National Selective Service in Washington

and they were favorably interested, but it was some several months later (August, 1942) before Occupational Bulletin No. 15 appeared, mentioning petroleum geologists and geophysicists on the recommended deferrable list. We have tried to do everything possible within our limitations to assist those desiring to enter military service and at the same time, have tried to encourage the conservation of personnel for needed exploration work.

In conclusion, we should like to state that, with our limited exploration personnel, we must work harder than ever and use all the tools, skill, and imagination at our command, not only to make up for our normal peace-time work, but also to make additional application of all the resourcefulness for which the geologist is outstanding.

We are very proud of the record of our membership and profession in entering the Armed Forces. The following excerpt from a sub-committee Report on Petroleum Investigation of the House of Representatives expresses our feeling in this respect.

> The service of no man is comparable to that of the man who offers his life for his country. The man who engages in essential production for war purposes makes a contribution that may be equally necessary to win the war, but whose services hardly rate with that of the man who offers his life for his country.

F. L. Aurin, *chairman*

Exhibit VII. Report of Distinguished Lecture Committee

At the Denver convention last year, the Association set up the distinguished lecture committee as a special committee to secure speakers for local affiliated society meetings, and authorized the advance of $500 as a revolving fund to facilitate the orderly arrangement of plans. This action was taken as a result of the report on similar activities by an informal committee during the previous year.

Following a survey of the wishes and requirements of the affiliated societies, the distinguished lecture committee felt that it would be desirable to plan for speakers to fill fifty engagements with an average of three well spaced lectures for each participating society. The ground-work for the year's activities was laid on that basis. After the first two speakers had finished their tours, the demand for visiting lecturers became so great that the subsequent speakers have had to follow enlarged itineraries. The result has been that fifty-three lectures have already been delivered, and twenty-four more are planned before the end of the first lecture season in June.

In accordance with the expressed desires of the representatives of the local societies, the subject matter of the lectures has been kept on a broad basis, concerned with new advances in the fundamentals of geology or in regional studies of geological provinces, which have significance to petroleum geologists. In all cases, outstanding authorities have been selected to speak on each subject.

The affiliated societies have responded enthusiastically to the opportunity to coöperate in this educational program, with the result that all but four have had speakers brought to them by the committee. Some of them will have heard as many as seven speakers before the season ends, others will have heard only two. Since this is a coöperative effort, whereby the group of societies which participate in a tour bears all the expense of that tour, it has been necessary for the committee to apportion the costs among the proper societies and collect them. The returns have been made as requested and the revolving fund of $500 is intact.

The committee feels that the program as carried on during the last 2 years has been successful in bringing directly to the largest possible number of geologists some of the new thoughts in geology, and has thereby stimulated the thinking of the men who are concerned with finding new oil fields. The committee recommends that the program be continued and extended, and that it be directed so that it will serve as a more definite educational force. The only change in the fundamental set-up of the committee to be recom-

mended at this time is that the revolving fund be increased to $1,000 to permit more satisfactory operation of the committee.

In view of the exigencies of the present situation, such as demand for increased wildcat development, increased demands on a geologist's time, and greatly restricted use of transportation facilities, the committee feels that every effort should be made to bring new geological thought directly to the working geologist. Therefore, it urges that every effort be made to keep the local societies strong, well organized and active in order that the ideas of the visiting speaker may be translated into useful equipment for their members. Means for making the committee and its program of maximum usefulness to the local societies will be discussed with the representatives of the local societies at a later meeting during this convention.

In closing, the committee wishes to thank Irving Levorsen and Walter Bucher for outstanding aid in securing well qualified speakers for the programs. Particularly, however, it wishes to express its appreciation of the self-sacrifice and Spartan courage shown by the men who agreed to carry out the rigorous itineraries arranged by the committee, in order to address a maximum number of interested geologists. These men are:

Kendall E. Born	Tennessee Division of Geology
Carey Croneis	University of Chicago
Sam H. Knight	University of Wyoming
Lewis B. Kellum	University of Michigan
Ernst Cloos	The Johns Hopkins University
John L. Rich	University of Cincinnati
Paul B. Krynine	The Pennsylvania State College

JOHN L. FERGUSON, *chairman*

EXHIBIT VIII. REPORT OF COMMITTEE ON COLLEGE CURRICULA IN PETROLEUM GEOLOGY

The committee on college curricula in petroleum geology last April submitted a report* which covered the results of its investigations during 2 years. This report also included a number of suggestions and recommendations. For the purpose of distributing this report and studying any further ideas that might be offered by those who might read it, the committee was reappointed to serve for another year. Accordingly, on August 1, printed copies of the report were sent with a brief letter of transmittal both to the president and to the head of the geological department of more than 70 American universities where geology is taught. Replies were received from nearly two-thirds of this number.

Most encouraging was the general reaction. This we may illustrate, for those of our members who may be interested, by the following quotations from a few of the letters received.

1. It appears to me that your committee has done a really outstanding job. I have no criticism to offer and no suggestions for improvement to make. You have taken a broad view of the whole situation and at the same time have recognized limiting conditions in different institutions.
2. This report contains a number of suggestions which we will find of practical use as we plan changes in our curriculum from time to time.
3. Reports of this kind are always most helpful to the administrative officers of a university. They help us in our study of the needs of the departments with which we have to deal.
4. I have read the report carefully and wish heartily to endorse it. The emphasis on broad training in fundamental principles seems especially happy not only in the training of petroleum geologists but in all fields of knowledge.
5. I have found it [the report] very interesing and informative. It gives exactly what one wishes to know concerning the type of studies that students planning to go into petroleum geology should take.

* Published on pp. 942 to 946, in Vol. 26 of the *Bulletin* of the Association, May, 1942.

6. I believe the work of the committee will cause many institutions to restudy and revise their offerings. . . . I personally know that the work of this committee has been very beneficial to the members of the staff of the Department of Geology of this university.

7. This report confirms an opinion that has been growing continuously on me during upwards of twenty-five years of college teaching. That opinion has not geen gained from the boys I have had in class nor from their parents, but from the better type of men who use these boys. I have talked with chemists, geologists, mining engineers, and other engineers and professors in graduate schools, and, although their opinions are not unanimous, it is certain that the vast majority of them have said to me, "Give the boys in college broad, fundamental training in Mathematics and the Sciences." It is very hard, however, for boys of college age to see the value of this. It also seems hard for parents, especially parents who are business-men, to see this point. . . . A report such as you have made will be a very useful thing to put into such students' hands. They will feel that it has a great deal more weight than the words of the college professor who may have rather warped ideas.

These quotations indicate that our report may be of use both to faculties and to students. If reports become exhausted the Association may eventually find that a second printing is desirable, particularly if—as some university geological departments have already done—lots of ten or a dozen reprints are requested for distribution to the students.

Although the report of our committee pertains essentially to conditions in normal times and to petroleum geology in particular, we believe that we may appropriately discuss some phases of the curricula of general geology as offered during the present abnormal period. As a matter of fact some of the current efforts may become permanently impressed on post-war teaching methods, especially the so-called accelerated programs of instruction.

One of the most interesting experiments of last year involved the offering, by Princeton University, of six field courses in geology, comprising two nine-weeks sequences, in the Big Horn Basin region of Wyoming. The first courses given (Introductory Physical and Historical Geology, Elements of Map-Making, and Elements of Structural Geology) were taken in the sequence named and were open to students as young as pre-seniors in High School. The first two of these courses will probably be offered again as parts of a six-weeks summer program for pre-college students. Regarding last year's experiment, Dr. W. T. Thom writes:

I was especially pleased with the results gotten by the pre-Freshmen among the number, for it has enabled them to plan for Freshman year with a clear decision that they did or did not wish to become professional geologists, and it has given an opportunity to judge whether they should be encouraged to go on in geo-exploration, or whether they have greater aptitude for other activities into which they should be steered.

This procedure gives the candidate for training in geology a chance to "catch up" in any elementary physics or chemistry or trigonometry, *et cetera*, that he ought to have for more advanced field work in the summer session preceding entrance into the college Freshman class. Obviously an accelerated schedule of this kind not only has several advantages in war time, but also, in peace time, it would have the additional advantage of providing opportunity for lengthening the period assigned to field work.

Another phase of the committee's recent investigations concerns the teaching of military geology, or of any related courses useful to army, navy, or air force. In February of this year, a brief questionnaire was mailed to the geological departments of the same colleges and universities to which our 1942 report had been sent. Replies were received from 70 of these institutions—a response of almost 100 per cent. These replies, when tabulated, indicated that Military Geology as such is being offered in only four or five universities; that the applications of geology to warfare (mineral resources) are being pointed out whenever appropriate in the regular geological courses of the curriculum in a considerable number of universities; and that certain other courses, related to geology, are being offered, in many universities, in part voluntary and in part as a requirement for trainees for army, navy, or air force, who are taking special preparation at these institutions. These "other courses, related to geology" deal with the uses and interpretation of maps (topo-

graphic, geologic, *et cetera*), offered by 37 of the universities; the interpretation of aerial photographs (in 17 universities); the construction of maps, mainly the making of military maps (in at least 6 universities); photogrammetry (in 4); meteorology, especially for aviation cadets (in 11); world geography (in 7); strategic minerals (in at least 2 or 3); and water supply (in 2 or 3). Registered in the courses in map interpretation and map construction are fully 7,000 students—probably many more—in groups of from 150 to over 2,000; and each of these groups is divided into several classes.

It would seem clear that the importance of a knowledge of maps for army, navy, and air force, and of meteorology for the air force, is definitely recognized; but there are many geologists who believe that not enough significance is attached to geology. They point out the facts that this science was shown to be valuable in the last war and that other nations, now fighting, have accepted it as extremely useful in the present war. Certainly there is a general and widespread eagerness on the part of many of the experienced professors of geology throughout the universities of the country to serve the nation by teaching military geology, and there is widespread disappointment among many of them because the military authorities, in their directives concerning the training of the armed forces, have not included geology, although they have singled out other special fields of science and engineering. As far as we have been able to ascertain, there are two main reasons for this attitude on the part of the general staffs of the armed forces. One is a failure to understand how geology may be applicable in war, and the other is the assumption that the science is too broad and complicated to be satisfactorily taught in the brief time available. In either case we must conclude, parenthetically, that we geologists have been remiss in failing long ago to explain these practical applications of geology in war.

From the suggestions contained in the replies to the questionnaire we may say that a course in military geology should include such topics as the following.

a. The geology of water resources, both surface and subsurface; their occurrence, recovery, and utilization. Also the rejuvenation of destroyed wells
b. The geology of earth (rock) materials for the construction of roads, airplane fields, fortifications, *et cetera*
c. The topography and physiography of land forms in relation to troop movements, military strategy and tactics
d. The nature of streams as bearing on their use as defense lines, as barriers to movement, and as aids in transportation
e. Types of shore lines and their relation to landing operations
f. The geology of soils
g. Quarrying operations

As far as we are aware there is no up-to-date comprehensive text on military geology. References being used in the few courses being now taught on this subject are: D. W. Johnson's "Battlefields of the World War"; and H. E. Gregory's "Military Geology and Geography."*

In the foregoing paragraphs we have merely summarized the replies to our questionnaire. Just what suggestions to make under existing circumstances is difficult to decide. We can say this, however, that something concrete *is* being done in the direction advocated by our correspondents. And we can say this, further, that although some think we may be too late to turn out young officers fully trained in geology for immediate application of the science in all of its appropriate phases, our committee does not agree that this is true. We are definitely of the opinion that a suitable course in military geology, embracing topics like those above listed, but excluding the many phases of the science not necessary for war, could be satisfactorily taught within the period of a year. Whether the present war lasts long or not, such a course should by all means be required as part of the training

* The Geological Society of America has recently published bibliographies of texts on military geology.

of officers in every branch of the service where tactics and strategy are in any manner based on geological conditions in the field. Until such a course is required by the military authorities, the geological departments of the various institutions should continue, in the courses now being given, to emphasize to their pupils any possible values of geology toward the War Effort. This they can do by citing pertinent examples and by making slight adaptations in the programs now in use in training geologists.† Probably much more can be accomplished by a reasonable and considered approach, repeated whenever fitting, than by an attitude of complaint or of criticism.

L. T. Barrow	Henry A. Ley
Walter R. Berger	J. T. Lonsdale
Hal P. Bybee	J. D. Marr
Ira H. Cram	E. K. Soper
W. P. Haynes	W. T. Thom, Jr.
K. K. Landes	F. H. Lahee, *chairman*

Exhibit IX. Report of Chairman of Research Committee

The following report covers the various activities of the research committee during the past year.

Tectonic map.—The publication of the tectonic map is set for the next few months, barring the unforeseen. The executive committee has let a contract with Williams and Heintz for an edition of 5,000 copies at a cost of $4,200 and the final copy is being checked now by Longwell and King. The Association will have spent the entire appropriation of $1,000 granted for drafting and other preliminary work by the time the map is completed, in addition to the contract price.

Geologic map of North America.—The publication of the geological map of North America is by the Geological Society of America. The material is prepared and the final engraving will soon be under way, but time of publication can not be announced as yet on account of the many possible delays due to pressure from war work. The Association made a contribution of $1,000 toward this map.

Petroleum discovery methods.—A symposium on discovery methods was held in Denver in which replies from 200 members to the question of their opinion as to the best approach to the problem of oil and gas discovery were discussed. The material was later photolithographed in an edition of 1,500 copies, of which two-thirds have been sold. It presents a cross section of representative geological opinion on this most important question.

Permian volume.—No progress on the Permian volume is reported by the editor, Ronald K. DeFord. He lists three reasons: (1) complete occupation of key contributors with the immediate war effort either in or out of the armed forces, (2) inability to find a draftsman, and (3) curtailment of travel which in turn curtails research on the subjects to be included in the volume.

Conferences.—The conference on the relation of oil analyses to detailed stratigraphy, under the leadership of N. W. Bass and L. Murray Neumann, has been discontinued for the reason that their objectives have been reached. The committee is developing a report on the mass of data which they have collected and it will be published, possibly in photolithograph form, when ready.

A new conference group has been started, the purpose of which is to discuss the problems surrounding the estimation of oil and gas reserves in connection with the appraisal of leases. Lewis MacNaughton and Harry Wright are the co-leaders of this conference and it should be one of continuing interest to many of our members.

† For example, men who are training for petroleum geology might prepare themselves for groundwater exploration and development by taking short courses in hydraulics and groundwater hydrology.

Sedimentation conference.—A conference on the place of sedimentation in petroleum geology was held at Denver and a stenotype report of the discussion was photolithographed in an edition of 1,200 copies which is nearly exhausted. From 50 to 75 persons were present and the discussion was lively and full of interesting ideas from start to finish.

Mimeographed publications.—The research committee has sponsored three photolithographed reports published by the Association in booklet form and sold at cost. They have been well received and we believe meet a definite demand and need of our members. In general we believe it very desirable for the Association to continue to publish material such as conference reports, progress reports, special data of either local or specialized interest, reprints of foreign literature, or any other kind of information in which a relatively few members are interested and which is not up to the standards required for publication in the *Bulletin*. This could easily expand into a substantial part of the Association publication program and it is recommended that it be continued wherever practical and desirable.

Annual survey of progress in petroleum geology.—A survey has been organized to present to the annual meeting the progress of the preceding year in the field of petroleum exploration. It is designed especially to review the progress in ideas, thinking, techniques, and report new trends in methods in contrast to the regular development reports which have been an annual feature of our meetings in the past. In order to establish the reports on a firm basis, the faculty of the Colorado School of Mines accepted the invitation to prepare the report for the first three years under the chairmanship of F. M. Van Tuyl. The reason for selecting a group such as this is because they have access to nearly all of the petroleum exploration literature of the world and have within the faculty persons who are interested in all phases of exploration and who follow developments in the various fields. The survey is to be from a world viewpoint and on all major fields of exploration such as geology, geophysics, paleontology, equipment, and so on.

South American special volume.—The Geographical Society of America has prepared at considerable expense a new base map of South America and the Geological Society of America is now preparing a geological map to be over-printed on the base map. In addition to being of wide usefulness, projects such as this go far toward promoting the "Good Neighbor" policy which our Government is sponsoring between North and South American countries.

The research committee recommends for favorable action by the Association the preparation of a special volume entitled "Geology of South America," to be published by the Association in a similar manner to its other special volumes. The material for this volume should consist of reprints of the important articles covering the general geology and stratigraphy in each country, which have been published in the foreign technical journals and publications. The articles to be published should be selected by a committee familiar with the geology of South America, and in general they should be selected as the type of material any petroleum geologist going to the country would ordinarily want to be familiar with. The cost of the volume would consist chiefly in the translations and the redrafting of the drawings into English titles. Such a volume should prove of great usefulness to many geologists who will be interested in South American problems in the post-war period and it is the kind of project that will do much to further the friendly relations between countries that our government is attempting to develop.

A. I. LEVORSEN, *chairman*

EXHIBIT X. REPORT OF REPRESENTATIVE ON DIVISION OF GEOLOGY AND GEOGRAPHY OF NATIONAL RESEARCH COUNCIL, 1942–1943

The annual meeting of the Division was held in Washington on May 2, 1942. During the past year the following activities of the Division are of interest to petroleum geologists.

Report of committee on sedimentation.—This is the report of the committee for 1940–41 which was published last year in mimeographed form and sold at $1.00 per copy. It contains 110 pages in mimeographed form with 10 special articles, several of which should be of especial interest to petroleum geologists. One article, "Diagenetic Changes in Calcareous Sediments," by George A. Thiel, is particularly worthy of note.

Other reports.—Mimeographed reports of the committees on paleobotany, micropaleontology, marine ecology, and measurement of geologic time, were issued during the year.

Correlation charts.—The committee under the chairmanship of Carl O. Dunbar which has been working since 1932 on the preparation of correlation charts of the Paleozoic and younger rocks of North America during the past year has completed and published two more charts as follows.

"Silurian Formations of North America," *Bull. Geol. Soc. America* (April, 1942), pp. 533–38. Charles K. Swartz, chairman.

"Devonian Sedimentary Formations of North America," *Bull. Geol. Soc. America* (December 1, 1942), pp. 1729–94. G. Arthur Cooper, chairman.

These charts represent much work and thought and should be of value to many petroleum geologists. Reports of other subcommittees on other systems will be published from time to time as the work is completed.

A.A.P.G. representative on Division.—My 3-year term as representative of the Association on the Division of Geology and Geography expires next June 30, after the annual meeting scheduled for May 1. Representatives are not eligible for reappointment after serving the regular 3-year term. It is my recommendation that the next representative of the Association also be the chairman of the Association research committee. There is much in favor of such a contact between these two research organizations and it brings the work of our committee in direct contact with that of the national committee.

A. I. LEVORSEN, *representative*

EXHIBIT XI. REPORT OF COMMITTEE ON GEOLOGIC NAMES AND CORRELATIONS

The committee on geologic names and correlations, first created to enforce uniform rules of nomenclature, has broadened its field to undertake constructive regional surveys of the use of geologic names and correlations. Petroleum geologists have addded a vast amount of new surface and subsurface information, since the time when most of the geologic names of formations, groups and series were proposed by early field geologists of the United States Geological Survey and various State surveys or by teachers in the universities and colleges. It is now highly desirable to review the nomenclature and correlations in the light of data now available. This is being done by subcommittees composed of competent, interested geologists chosen from the districts where information is available.

The Permian subcommittee really started this program with its review of the Permian of West Texas. They described a standard Permian section for that area and recommended that the Permian series be removed from the Carboniferous system and advanced to system rank itself. Their recommendations were generally accepted and later the United States Geological Survey also declared the Permian a system.

Next, the Carboniferous subcommittee was formed, with M. G. Cheney as chairman, to consider the Pennsylvanian and Mississippian and to determine whether they likewise should be called systems, and to study the desirability of standard sections or simplification and elimination of some names. They have worked several years and planned to submit a final report at this meeting, but it will be delayed because several committee members are now in the armed services. A majority of the subcommittee apparently favor the elimination of the term Carboniferous in the United States, and the advancement of the Pennsylvanian and Mississippian from series to system rank. Most of the State geological surveys and practically all petroleum geologists follow that usage now but the United States Geo-

logical Survey still retains the Carboniferous. A minority of the subcommittee believe that conformity with world usage is very important and insist that Carboniferous should be retained, because geologists in other countries are unwilling to adopt the American terms, Pennsylvanian and Mississippian. Regarding standard sections, it is agreed that there should be at least two in this country, one for the Appalachian area and one for the Mid-Continent area, but the units of these two sections can be correlated. In the matter of names, it is not yet known what the final recommendations will be. Progress has been made in the location of group and series boundaries, so that the same points may be picked in the sections in different areas, but uniform names for wide areas may not be desirable and may not be recommended. If geologists know that the base of the Cisco and Virgil are placed at approximately the same point, there is no great need to try to force geologists in Texas to call their Cisco the Virgil or geologists in Kansas to call the Virgil the Cisco. When the subcommittee's work is completed, its report will be published in the *Bulletin* and will be of real value.

In 1941, a Tertiary subcommittee was appointed, under the chairmanship of W. Armstrong Price, to review the nomenclature and correlations of post-Cretaceous rocks mostly in the Gulf Coast region. Members of the subcommittee were selected from the different geologic centers in the Gulf Coast, and, in turn, several of these members formed committees or study groups in the local geological societies. Their work is making good progress, particularly at Houston and San Antonio. In a year or so they will have definite results to report.

Recently, a Mesozoic subcommittee was formed, with R. W. Imlay as chairman and is organizing now. They will study the Triassic, Jurassic, Lower and Upper Cretaceous and their work will last several years.

No plans have yet been made to cover the early Paleozoic, Cambrian, Ordovician, Silurian, and Devonian, in this manner and it is not known whether the committee will consider that advisable or necessary. While the present subcommittees are set up to do a specific task and then disband, the chairman believes that some day in the future it may be desirable to have permanent groups on the Paleozoic, Mesozoic, and Tertiary to continually study and advise on regional problems of nomenclature.

The committee members have also carried on their regular duties of giving assistance to the editorial department and to individual geologists whenever desired. In some areas, the work has been interrupted because committeemen went to war, and in other areas their professional and extra civilian defense duties left little time for committee activities. Geologic names are not very important during a war crisis, but the organization will continue to function and make some progress.

John G. Bartram, *chairman*

Exhibit XII. Report of Committee on Applications of Geology

A. The committee on applications of geology, after carefully reviewing its activities for this past year, makes the following recommendations to the business committee.

1. That it request the executive committee to define and delimit more precisely the duties of the committee on applications of geology, and
2. That it request the executive committee to consider a complete integration of the duties of the committee on applications of geology and those of the interrelated committee on college curricula in petroleum geology and the national service and distinguished lecture committees.

B. A subcommittee of the committee on applications of geology, comprised of George S. Buchanan, Henry C. Cortes, C. E. Dobbin, Paul Price, B. B. Weatherby, and Paul Weaver, considered the most important problem before the committee on applications of geology, namely, the improvement of the national standing of all phases of the geological sciences, in order that they may be of greater service to the nation, both in war and in peace; and it makes the following recommendation.

1. Inasmuch as the war has clearly demonstrated, even to those who previously doubted it, the fact that the geological sciences do not occupy a position sufficiently high in the national esteem and consciousness to be utilized fully in the interests of our Country, we therefore urge that the members of the A.A.P.G. and its sister societies, the Geological Society of America, the Society of Exploration Geophysicists, the Society of Economic Paleontologists and Mineralogists, the Society of Economic Geologists, the Paleontological Society, the Mineralogical Society, Section E of the American Association for the Advancement of Science, and geologists belonging to various engineering societies, such as the A.I.M.E., and members of the State and Federal geological surveys lend their individual support to a concerted action designed to remedy this unwholesome situation, and

2. Although we are not now in a position to recommend the form in which this action should express itself, we strongly urge that all individual differences, and the short-term interests of individual societies, be subordinated to the long-term common good of our profession, so that the organizational meeting for the establishment of an American Geological Association may bear fruitful results, not only for all persons associated in the study of the earth sciences, but for the Nation.

R. M. Barnes	Wesley G. Gish	Paul H. Price
Geo. S. Buchanan	K. K. Landes	Gayle Scott
Henry C. Cortes	M. M. Leighton	B. B. Weatherby
C. E. Dobbin	H. S. McQueen	Paul Weaver
		Carey Croneis, *chairman*

Exhibit XIII. Report of Committee for Publication

In view of the fact that the editor has had in hand during 1942 ample material to supply the *Bulletin* until mid-1943, the usual function of this committee, solicitation of papers, appeared superfluous. Therefore the chairman, late in the year, wrote each member, requesting that they submit ideas for improvement of the *Bulletin* and for their reaction to certain specific suggestions that had been made. Written replies were received from 7 members, and 9 were present. The report, therefore, expresses the opinion of 16 out of 22 members.

The committee wishes to take this means to express their appreciation of the work of Dr. Ver Wiebe as editor for the past 6 years, during which time he has maintained its high standard among technical publications. From none of the membership have there been other than minor criticisms, and it is recommended unhesitatingly that no drastic changes be considered.

Certain recommendations are made, with the hope that they may assist the editor who may succeed Dr. Ver Wiebe. These are:

1. All members contacted believe that we should continue to encourage the publication of non-technical articles of general interest to the profession.

2. In the annual Review of Development, it is recommended that greater emphasis be placed on the geological aspects of development, and less on statistics, which is now being covered by several other groups.

3. The committee (one member dissenting) favors continuation of the effort to record, at the time, as much information as possible concerning new and important discoveries, particularly identifying the method or methods which led to the drilling of the discovery wells. The object should be to give a case history of the discovery thinking, and not a classification of the dominant discovery methods. It is our opinion that most discoveries are due to use of more than one method, and that statistical methods do not give an accurate picture.

4. We suggest that the editor, from time to time, inform the members of this committee concerning the supply of papers on hand, their geographical distribution, and type, together with a statement of the kinds of papers needed in order to maintain a proper balance. If this is done, the members can better cooperate in obtaining the type needed.

Following oral report to the business committee, the following suggestions were made, and added to the foregoing.

A. Consideration may well be given to the suggestion that the committee for publication take over the work of preparing the annual review papers, so that this would have better continuity.

B. A majority of the business committee strongly favored the recommendation in *3* above, and emphasized also the giving of due credit to individuals and organizations involved.

C. Suggestions were made that greater effort be made to furnish brief notes on local geological discoveries, changes in correlations, *et cetera*, probably in the form of geologic notes. These might well be handled either through the local societies or through members of this committee.

D. In line with *2* above, it was further suggested that the A.A.P.G. cooperate with the other organizations preparing annual review of development, to the end that each group lay emphasis on a different phase of the subject, and avoid all possible duplication.

The chairman wishes to thank the committee for willing and sincere cooperation, and to suggest to the new chairman, and the incoming editor, that the committee for publication, with its widely scattered personnel, be given more work to do in the coming year.

J. V. HOWELL, *chairman*

MINUTES OF BUSINESS COMMITTEE TEXAS HOTEL, FORT WORTH, TEXAS

APRIL 7, 1943

The meeting was called to order at 10:30 A.M. by D. Perry Olcott, chairman.

The following members were present.

Executive committee: Fritz L. Aurin, Paul Weaver, E. O. Markham,—and Ed. W. Owen and W. A. Ver Wiebe, by proxy

Business committee: D. Perry Olcott, chairman; Roy M. Barnes, vice-chairman (represented by Robert W. Clark); E. O. Markham, secretary

Members-at-large: A. R. Denison, K. C. Heald, J. V. Howell, W. B. Wilson, Frank A. Morgan

Division of Paleontology: Herschel L. Driver, H. B. Stenzel

District Representatives:

Amarillo: Archie R. Kautz (represented by John S. Van Sant)
Capital: L. W. Stephenson (represented by Ralph W. Imlay)
Dallas: Dilworth S. Hager
East Oklahoma: T. C. Hiestand
Fort Worth: C. E. Yager
Great Lakes: Darsie A. Green, L. E. Workman
Houston: Marcus A. Hanna, Phil F. Martyn, R. C. Bowles, Leslie Bowling
New Mexico: Neil H. Wills
Pacific Coast: W. D. Kleinpell, Karl Arleth, Max L. Krueger
Rocky Mountain: C. S. Lavington
Shreveport: C. C. Clark
Southeast Gulf: Urban B. Hughes
Southern Louisiana: Dean F. Metts
So. Permian Basin: C. D. Vertrees
South Texas: Robert N. Kolm
Tyler: George W. Pirtle
West Oklahoma: D. A. McGee
Wichita: John L. Garlough
Wichita Falls: W. C. Bean

1. *Seating of representatives.*—Motion was made, seconded, and carried that members of the business committee not present at roll call may be recorded by the secretary if they report to him at the close of the session.

2. *Minutes of previous meeting.*—It was moved, seconded, and carried that the reading of the minutes of the last meeting of the committee be dispensed with, as they had been published in the *Bulletin*, and that the minutes of said meeting be adopted without change.

3. *Report of special distinguished lecture committee, John L. Ferguson, chairman* (*Exhibit VII*).—Motion was made, seconded, and carried unanimously that the report, with its recommendations, be accepted and referred to the annual business meeting, with the recommendation that it be not read, but that it be published in the *Bulletin.*

4. *Report of committee on geologic names and correlations, John G. Bartram, chairman* (*Exhibit XI*).—After the presentation of this report, it was moved, seconded, and carried that the report be accepted and referred to the annual business meeting, with the recommendation that it be not read but that it be published in the *Bulletin.*

5. *Report of special national service committee, F. L. Aurin, chairman* (*Exhibit VI*).—It was moved, seconded, and carried that this report be accepted and referred to the annual business meeting, with the recommendation that it be published in the *Bulletin.*

6. *Report of representative to the Division of Geology and Geography, National Research Council, A. I. Levorsen, chairman* (*Exhibit X*).—After presentation of this report, the motion was made, seconded, and carried that it be accepted and referred to the annual business meeting, with the recommendation that it be not read, but that it be published in the *Bulletin.*

7. *Report of research committee, A. I. Levorsen, chairman* (*Exhibit IX*).—After presentation of this report, the motion was made, seconded, and carried that it be accepted and referred to the annual business meeting, with the recommendation that it be not read, but that it be published in the *Bulletin.*

Adjournment of the morning session was at 11:45 A.M.

(Recess)

The meeting was called to order at 2:00 P.M. by D. Perry Olcott, chairman.

8. *Report of special committee on college curricula in petroleum geology, F. H. Lahee, chairman* (*Exhibit VIII*).—After the reading of the report, it was moved, seconded, and carried unanimously that the report, with its recommendations, be accepted and presented to the annual business meeting, with the recommendation that it be not read, but that it be published in the *Bulletin.*

9. *Report of committee for publication, J. V. Howell, chairman* (*Exhibit XIII*).—After a brief review of the activities and recommendations of the committee, it was moved, seconded, and carried unanimously that the written report be referred to the annual business meeting, with the approval of the business committee, and that it be not read but that it be published in the *Bulletin.*

10. *Report of committee on applications of geology, Carey Croneis, chairman* (*Exhibit XII*).—After presentation of the report, it was moved, seconded, and carried that the report, with its recommendations, be accepted and referred to the business meeting, with the recommendation that it be not read, but that it be published in the *Bulletin.*

11. *New Business.*

A. Herschel L. Driver offered the following motion: I move that the business committee recommend to the meeting of the Association that a fund of $1,500 be granted the S.E.P.M. during the year 1943. The motion was seconded and passed unanimously.

B. F. L. Aurin presented recommendations made by the executive committee to the business committee as follows.

BE IT RESOLVED, by the voting members of the American Association of Petroleum Geologists, duly assembled at the annual meeting held in the City of Fort Worth, County of Tarrant, and State of Texas, on the 9th day of April, 1943, that the members of the executive committee of the American Association of Petroleum Geologists be, and they are hereby, authorized to make application to the Secretary of State of the State of Colorado for renewal and extension of the certificate of incorporation of the American Association of Petroleum Geologists, and are also authorized to take any additional steps in connection therewith that the executive committee deems necessary, for a period of twenty years from April 21, 1944, and to pay the expenses of such renewal and extension out of the funds now on hand belonging to said Association.

Motion was made, seconded, and carried that this resolution be accepted and presented to the annual business meeting.

The executive committee takes this opportunity to express their great joy that the war situation is certainly less threatening than it was at this time last year and that the continued support by the membership has resulted in an actual growth of the Association, and in view of the success which has attended this meeting, they recommend to the business committee that no amendments to the Constitution be introduced at this time.

Motion was made, seconded, and carried that the two groups, the Corpus Christi Geological Society and the New Orleans Geological Society, be included among the A.A.P.G. affiliated societies.

An amendment to the by-laws of the Association was proposed by A. R. Denison, seconded, and carried unanimously, as follows.

Amend Article VI, Section 1, so as to add, at the end of the first paragraph—"and medal award committee." Amend the second paragraph of Section 1, which starts—"The president shall appoint . . . " to read as follows: "The president shall appoint all standing committees except the business committee *and the medal award committee*, for which provisions are hereafter made."

Add a new section (Number 11) to Article VI which shall be as follows.

Medal Award Committee

"Section 11—The purpose of the committee shall be to choose recipients for all medals or other awards which may be established by the executive committee.

"The committee shall consist of nine members and three ex-officio members. The nine members of the original committee shall be appointed by the president, three of whom shall serve for three years, three for two years, and three for one year. One of each of the groups appointed for the different lengths of time shall be a former president of the Association. Each incoming president shall thereafter appoint three members of the committee to serve for three years, one of which shall be a former president of the Association. Vacancies on the committee due to resignation or other causes shall be immediately filled by the president. The ex-officio members shall be: (1) the president of the Association, (2) the president of the Society of Exploration Geophysicists, (3) the president of the Society of Economic Paleontologists and Mineralogists. The president of the Association shall be the chairman of the committee unless he shall, at his election, name a chairman to serve for one year."

The meeting was adjourned at 4:15 P.M.

PERRY OLCOTT, *chairman* E. O. MARKHAM, *secretary*

BULLETIN OF THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS
VOL. 27, NO. 5 (MAY, 1943), PP. 705-712

THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS

CONSTITUTION[1]

ARTICLE I. NAME

This Association shall be called "The American Association of Petroleum Geologists," incorporated under the laws of Colorado the 21st day of April, 1924, for a period of twenty (20) years.

ARTICLE II. OBJECT

The object of this Association is to promote the science of geology, especially as it relates to petroleum and natural gas; to promote the technology of petroleum and natural gas and to encourage improvements in the methods of exploring for and exploiting these substances; to foster the spirit of scientific research amongst its members; to disseminate facts relating to the geology and technology of petroleum and natural gas; to maintain a high standard of professional conduct on the part of its members; and to protect the public from the work of inadequately trained and unscrupulous persons posing as petroleum geologists.

ARTICLE III. MEMBERSHIP

Members

SECTION 1. Any person engaged in the work of petroleum geology or in research pertaining to petroleum geology or technology is eligible to active membership, provided he is a graduate of an institution of collegiate standing, in which institution he has done his major work in geology, or in sciences fundamental to petroleum geology, and in addition has had the equivalent of three years' experience in petroleum geology or in the application of these other sciences to petroleum geology or to research in petroleum geology or technology; and provided further that in the case of an applicant for membership who has not had the required collegiate or university training, but whose standing in the profession is well recognized, he shall be admitted to membership when his application shall have been favorably and unanimously acted upon by the executive committee; and provided further that these requirements shall not be construed to exclude teachers and research workers in recognized institutions, whose work is of such character as in the opinion of the executive committee shall qualify them for membership.

Active members alone shall be known as members.

Life Members

SECTION 2. The executive committee may grant life membership to members who have paid their dues and are otherwise qualified.

Associates

SECTION 3. Any person having completed as much as thirty hours of geology (an hour shall here be interpreted as meaning as much as sixteen recitation or lecture periods of one hour each, or the equivalent in laboratory) in a reputable institution of collegiate or university standing, or who has done field work equivalent to this, is eligible to associate membership, provided at the time of his application for membership he shall be engaged in geological

[1] The constitution and by-laws were adopted 1918, and amended 1921, 1922, 1923, 1925, 1927, 1928, 1929, 1930, 1932, 1933, 1935, 1936, 1939, 1940, 1942, and 1943.

studies in an institution of collegiate or university standing, or shall be engaged in petroleum geology; and any person who is a graduate of an institution of collegiate standing in which he has done his major work in sciences fundamental to petroleum geology or petroleum technology, and who has the equivalent of one year's experience in the application of his science to the study of petroleum geology, shall be eligible to associate membership, provided at the time of his application for membership he shall be engaged in investigations in the broader subject of petroleum geology and technology.

Associate members shall be known as associates.

Associates shall enjoy all the privileges of membership in the Association, save that they shall not hold office, sign applications for membership, or vote; neither shall they have the privilege of advertising their affiliation with the Association in professional cards or professional reports or otherwise.

The executive committee may advance to active membership, without the formality of application for such change, those associates who have, subsequent to election, fulfilled the requirements for active membership.

Election to Membership

SECTION 4. Every candidate for admission as a member or associate shall submit a formal application on an application form authorized by the executive committee, signed by him, and endorsed by not less than three members who are in good standing, stating his training and experience and such other facts as the executive committee shall from time to time prescribe. Provided the executive committee, after due consideration, shall judge that the applicant's qualifications meet the requirements of the constitution, they shall cause to be published in the *Bulletin* the applicant's name and the names of his sponsors. If, after at least thirty days have elapsed since such publication, no reason is presented why the applicant should be not admitted, he shall be deemed eligible to membership or to associate membership, as the case may be, and shall be notified of his election.

SECTION 5. An applicant for membership, on being notified of his election in writing, shall pay full membership dues for the current year and on making such payment shall be entitled to receive the entire *Bulletin* for that year. Unless payment of dues is made within thirty (30) days by those living within the continental United States and within ninety (90) days by those living elsewhere, after notice of election has been mailed, the executive committee may rescind the election of the applicant. Upon payment of dues, each applicant for membership shall be furnished with a membership card for the current year, and until such written notice and card are received, he shall in no way be considered a member of the Association.

Honorary Members

SECTION 6. The executive committee may from time to time elect as honorary members persons who have contributed distinguished service to the cause of petroleum geology. Honorary members shall not be required to pay dues.

ARTICLE IV. OFFICERS AND THEIR DUTIES

Officers

SECTION 1. The officers of the Association shall be a president, a vice-president, a secretary-treasurer, and an editor. These, together with the past-president, shall constitute the executive committee and managers of the Association.

SECTION 2. The officers shall be elected annually from the Association at large by written ballot deposited in a locked ballot box by those members, present at the annual meeting, who have paid their current dues and are otherwise qualified under the constitution. Each candidate, when voted for as a candidate for the particular office for which he

is nominated, shall be thereby automatically voted for as a candidate for the executive committee for one year, except that candidates for the presidency shall be automatically voted for as candidate for the executive committee for two years.

SECTION 3. No one shall hold the office of president for two consecutive years and no one shall hold any other office for more than two consecutive years except the editor who shall not hold office for more than six consecutive years.

Duties of Officers

SECTION 4. The president shall be the presiding officer at all meetings of the Association, shall take cognizance of the acts of the Association and of its officers, shall appoint such committees as are required for the purposes of the Association, and shall delegate members to represent the Association. He may, at his option, serve on, and may be chairman of, any committee.

SECTION 5. The vice-president shall assume the office of president in case of a vacancy from any cause in that office and shall assume the duties of president in case of the absence or disability of the latter. If the past-president shall for any reason be unable to serve as a member of the executive committee, the president shall fill the vacancy by the appointment of the next available preceding past-president.

A vacancy or disability occurring in the office of vice-president, secretary-treasurer, or editor shall be filled by majority vote of the executive committee, either for the unexpired term or for the period of disability, as the committee may decide. In the case of a tie, the president shall cast the deciding vote.

SECTION 6. The secretary-treasurer shall assume the duties of president in case of the absence of both the president and vice-president. He shall have charge of the financial affairs of the Association and shall annually submit reports as secretary-treasurer covering the fiscal year. He shall receive all funds of the Association, and, under the direction of the executive committee, shall disburse all funds of the Association. He shall cause an audit to be prepared annually by a public accountant at the expense of the Association. He shall give a bond, and shall cause to be bonded all employees to whom authority may be delegated to handle Association funds. The amount of such bonds shall be set by the executive committee and the expense shall be borne by the Association. The funds of the Association shall be disbursed by check as authorized by the executive committee.

SECTION 7. The editor shall be in charge of editorial business, shall submit an annual report of such business, shall have authority to solicit papers and material for the *Bulletin* and for special publications, and, with the approval of the executive committee, may accept or reject material offered for publication. He may appoint associate, regional, and special editors.

SECTION 8. The officers shall assume the duties of their respective offices immediately after the annual meeting in which they are elected.

ARTICLE V. EXECUTIVE COMMITTEE—MEETINGS AND DUTIES

Executive Committee

SECTION 1. The executive committee shall consist of the president, past-president, vice-president, secretary-treasurer, and editor.

Meetings and Duties

SECTION 2. The executive committee shall meet immediately preceding the annual meeting and at the call of the president may hold meetings when and where thought advisable, to conduct the affairs of the Association. A joint meeting of the outgoing and incoming executive committees shall be held immediately after the close of the annual Asso-

ciation business meeting. Members of the executive committee may vote by proxy on matters which require a unanimous vote.

SECTION 3. The executive committee shall consider all nominations for membership and pass on the qualifications of the applicants; shall have control and management of the affairs and funds of the Association; shall determine the manner of publication and pass on the material presented for publication; and shall designate the place of the annual meeting. They are empowered to establish a business headquarters for the Association, and to employ such persons as are needed to conduct the business of the Association. They are empowered to accept, create, and maintain special funds for publication, research, and other purposes. They are empowered to make investments of both general and special funds of the Association. Trust funds may be created, giving to the trustees appointed for such purpose, such direction as to investments as seems desirable to the executive committee to accomplish any of its objects and purposes, but no such trust funds shall be created unless they are revocable upon ninety (90) days' notice.

ARTICLE VI. MEETINGS

The Association shall hold at least one stated meeting each year, which shall be the annual meeting. This meeting shall be held in March or April at a time and place designated by the executive committee. At this meeting the election of members shall be announced, the proceedings of the preceding meeting shall be read, Association business shall be transacted, scientific papers shall be read and discussed and officers for the ensuing year shall be elected.

ARTICLE VII. AMENDMENTS

Amendments to this constitution may be proposed by a resolution of the executive committee, by a constitutional committee appointed by the president, or in writing by any ten members of the Association. All such resolutions or proposals must be submitted at the annual meeting of the business committee of the Association as provided in the by-laws, and only the business committee shall make recommendations concerning proposed constitutional changes at the annual Association business meeting. If such recommendations by the business committee shall be favorably acted on at the annual Association business meeting, the secretary-treasurer shall arrange for a ballot of the membership by mail within thirty (30) days after said annual Association business meeting, and a majority vote of the ballots received within ninety (90) days of their mailing shall be sufficient to amend. The legality of all amendments must be determined by the executive committee prior to balloting.

BY-LAWS

ARTICLE I. DUES

SECTION 1. The fiscal year of the Association shall correspond with the calendar year.

SECTION 2. The annual dues of members of the Association shall be ten dollars($10.00). The annual dues of associates for not to exceed three years after election shall be six dollars ($6.00); for the second three-year period eight dollars ($8.00); thereafter, the annual dues of such associates shall be ten dollars ($10.00). The annual dues are payable in advance on the first day of each calendar year. A bill shall be mailed to each member and associate before January first of each year, stating the amount of the annual dues and the penalty and conditions for default in payment. Members or associates who shall fail to pay their annual dues by April first shall not receive copies of the April *Bulletin* or succeeding *Bulletins*, nor shall they be privileged to buy Association special publications at prices made to the membership, until such arrears are met.

During any period in which the United States is actually engaged in war and for a period of one year thereafter, the executive committee may at its discretion suspend, reduce, or waive annual dues to members or associate members serving in the armed forces

of the United States or any allied country, without otherwise affecting their membership, except that they shall not receive the *Bulletin* during a period for which no dues are paid.

SECTION 3. On the payment of two hundred dollars ($200.00) any member in good standing shall be declared a life member and thereafter shall not be required to pay annual dues. The funds derived from this source shall be placed in a permanent investment, the income from which shall be devoted to the same purposes as the regular dues.

ARTICLE II. RESIGNATION—SUSPENSION—EXPULSION

SECTION 1. Any member or associate may resign from the Association at any time. Such resignation shall be in writing and shall be accepted by the executive committee, subject to the payment of all outstanding dues and obligations of the resigning member or associate.

SECTION 2. Any member or associate who is more than a year delinquent (in arrears) in payment of dues shall be suspended from the Association. Any delinquent or suspended member or associate, at his own option, may request in writing that he be dropped from the Association and such request shall be granted by the executive committee. Any member or associate more than two years in arrears shall be dropped from the Association. The time of payment of delinquent dues for either one year or two years may be extended by unanimous vote of the executive committee.

SECTION 3. Any member or associate who resigns or is dropped under the provisions of Sections 1 and 2 of this article ceases to have any rights in the Association and ceases to incur further indebtedness to the Association.

SECTION 4. Any person who has ceased to be a member or associate under Section 1 or Section 2 of this article may be reinstated by unanimous vote of the executive committee subject to the payment of any outstanding dues and obligations which were incurred, prior to the date when he ceased to be a member or associate of the Association.

In the case of any member or associate who has been dropped between the dates of January 1, 1931, and January 1, 1936, for non-payment of dues and who shall apply for reinstatement, the executive committee is authorized, at its discretion, to accept the resignation of such member or associate effective at any date during such period of delinquency, provided, the member shall pay all indebtedness to the Association incurred prior to the date of such resignation including a proper proportion of annual dues as shall be fixed by the executive committee. Such member or associate shall not be entitled to receive the *Bulletin* for any period subsequent to the date when his resignation became effective and prior to his reinstatement.

SECTION 5. Any member or associate who, after being granted a hearing by the executive committee, shall be found guilty of a violation of the code of ethics of this Association or shall be found guilty of a violation of the established principles of professional ethics, or shall be found guilty of having made a false or misleading statement in his application for membership in the Association, may be suspended or expelled from the Association by unanimous vote of the executive committee. The decision of the executive committee in all matters pertaining to the interpretation and execution of the provisions of this section shall be final.

ARTICLE III. PUBLICATIONS

SECTION 1. The proceedings of the annual meeting and the papers presented at such meeting shall be published at the discretion of the executive committee in the Association *Bulletin* or in such other form as the executive committee may decide best meets the needs of the membership of the Association.

SECTION 2. The payment of annual dues for any fiscal year entitles the member or associate to receive without further charge a copy of the *Bulletin* of the Association for that year.

SECTION 3. The executive committee may authorize the printing of special publications to be financed by the Association from its general, publication, or special funds and offered for sale to members and associates in good standing at not less than cost of publication and distribution.

ARTICLE IV. REGIONAL SECTIONS, TECHNICAL DIVISIONS, AND AFFILIATED SOCIETIES

SECTION 1. Regional sections of the Association may be established provided the members of such sections are members of the Association and shall perfect an organization and make application to the executive committee. The executive committee shall submit the application to a vote at a regular annual meeting, an affirmative vote of two-thirds of the members present and voting being necessary for the establishment of such a section; and provided that the Association may revoke the charter of any regional section by a vote of two-thirds of the members present and voting at a regular annual meeting.

SECTION 2. Technical divisions may be established, provided the members interested shall perfect an organization and make application to the executive committee. The executive committee shall submit the application to a vote at a regular meeting, an affirmative vote of two-thirds of the membership present and voting being necessary for the establishment of such a division. In like manner, the Association may dissolve a division by an affirmative vote of two-thirds of the members present and voting at any annual meeting. A technical division may have its own officers, and it may have its own constitution and by-laws provided that, in the opinion of the executive committee, these do not conflict with the constitution and by-laws of the Association. The executive committee shall be empowered to make arrangements with the officers of the division for the conduct of the business of the division. A division may admit to affiliate membership in the division specially qualified persons who are not eligible to membership in the Association. Technical divisions may affiliate with other scientific societies, with the approval of the executive committee.

SECTION 3. Subject to the affirmative vote of two-thirds of the membership present and voting at an annual meeting, and with legal advice, the executive committee may arrange for the affiliation with the Association of duly organized groups or societies, which by objects, aims, constitutions, by-laws, or practice are developing the study of geology or petroleum technology. In like manner and with like advice, the executive committee may arrange conditions for dissolution of such affiliations. Affiliation with the Association need not prevent affiliation with other scientific societies. Members of affiliated societies who are not members of the Association, shall not have the privilege of advertising their affiliation with the Association on professional cards or otherwise.

ARTICLE V. DISTRICT REPRESENTATIVES

The executive committee shall cause to be elected district representatives from districts which it shall define by a local geographic grouping of the membership. Such districts shall be redesignated and redefined by the executive committee as often as seems advisable. Each district shall be entitled to one representative for each seventy-five members, but this shall not deprive any designated district of at least one representative. The representatives so apportioned shall be chosen from the membership of the district by a written ballot arranged by the executive committee. They shall hold office for two years, their term of office expiring at the close of the annual meeting.

ARTICLE VI. COMMITTEES

Appointment and Tenure

SECTION 1. There shall be the following standing committees: business committee; research committee; committee on geologic names and correlations; committee on appli-

cations of geology; committee for publication; finance committee; trustees of revolving publication fund; trustees of research fund; and medal award committee.

The president shall appoint all standing committees except the business committee and the medal award committee, for which provision is hereafter made. Members of all committees except the business committee shall serve for a three-year term, but in rotation, with one-third of the members being appointed each year. The president shall designate the chairmen, annually, shall have power to fill vacancies, and shall notify the members of the committees of their appointment. The president may designate one or more vice-chairmen annually.

In addition to the aforesaid standing committees, the president shall appoint annually or semiannually a resolutions committee, and such special committees as the executive committee may authorize. Special committees shall be appointed for a term of one year. The president shall designate the chairmen of such committees.

Business Committee

SECTION 2. The business committee shall act as a council and advisory board to the executive committee and the Association. This committee shall consist of the executive committee, not more than five members at large appointed annually by the president, two members elected by and from each technical division, and the district representatives. The president shall also appoint annually a chairman and a vice-chairman, but neither of these need be one of those otherwise constituting the business committee. The secretary-treasurer shall act as secretary of the business committee. If a district or technical representative is unable to be present at any meeting of the committee he may designate an alternate, who, in the case of a district representative, may or may not be a resident of the district he is asked to represent, and the alternate, on presentation of such a designation in writing, shall have the same powers and privileges as a regularly chosen representative. The business committee shall meet the day before the annual meeting at which all proposed changes in the constitution or by-laws shall be considered, all old and new business shall be discussed, and recommendations shall be voted for presentation at the annual meeting.

Research Committee

SECTION 3. The purpose of the research committee is the advancement of research, particularly within the field of petroleum geology. The committee shall consist of twenty-four members unless a different number is authorized by the executive committee.

Committee on Geologic Names and Correlations

SECTION 4. The purpose of the committee on geologic names and correlations is to lend assistance to authors on problems on stratigraphy and nomenclature and to advise the editor and executive committee in regard to the propriety of the use of stratigraphic names and correlations in papers submitted for publication by the Association. The committee shall consist of fifteen members unless a different number is authorized by the executive committee.

Committee on Applications of Geology

SECTION 5. The object of the committee on applications of geology is to advise and promote ways and means for informing the general public on all phases of geology particularly on the natural occurrence of oil and gas underground, the methods of searching for these substances, and the methods of exploiting them. The committee shall consist of twelve members unless a different number is authorized by the executive committee.

Committee for Publication

SECTION 6. The purpose of the committee for publication is to assist in securing desirable manuscripts for publication in the *Bulletin* or other publications of the Association. The committee may also assist in securing papers for delivery at the annual meetings. The committee shall consist of twenty-four members unless a different number is authorized by the executive committee.

Finance Committee

SECTION 7. The finance committee shall act as financial advisers to the executive committee. The committee shall consist of three members. If a member of the finance committee should be elected to the executive committee he shall resign from the finance committee and the president shall appoint a member of the Association to complete his unexpired term.

Trustees of Revolving Publication Fund

SECTION 8. Before any publication project shall be undertaken with the use of the revolving publication fund the approval of the trustees and the executive committee must be secured. There shall be three trustees. If a trustee should be elected to the executive committee he shall resign as a trustee and the president shall appoint a member of the Association to complete his unexpired term.

Trustees of Research Fund

SECTION 9. Before any research work may be undertaken with the use of money from the research fund, the approval of the trustees and the executive committee shall be secured. There shall be three trustees. If a trustee shall be elected to the executive committee he shall resign as a trustee and the president shall appoint a member of the Association to complete his unexpired term.

Resolutions Committee

SECTION 10. The resolutions committee shall be charged with the duty of presenting at the annual and semi-annual meetings resolutions expressing the Association's appreciation and thanks to those who have worked and contributed to the success of the meetings.

Medal Award Committee

SECTION 11. The purpose of the committee shall be to choose recipients for all medals or other awards which may be established by the executive committee. The committee shall consist of nine members and three ex-officio members. The nine members of the original committee shall be appointed by the president, three of whom shall serve for three years, three for two years, and three for one year. One of each of the groups appointed for the different lengths of time shall be a former president of the Association. Each incoming president shall thereafter appoint three members of the committee to serve for three years, one of which shall be a former president of the Association. Vacancies on the committee due to resignation or other causes shall be immediately filled by the president. The ex-officio members shall be: (1) the president of the Association, (2) the president of the Society of Exploration Geophysicists, (3) the president of the Society of Economic Paleontologists and Mineralogists. The president of the Association shall be the chairman of the committee unless he shall, at his election, name a chairman to serve for one year.

ARTICLE VII. AMENDMENTS

These by-laws may be amended by vote of three-fourths of the members present and voting at any annual meeting, provided that such changes shall have been recommended to the meeting by the business committee and provided that their legality shall be determined by the executive committee prior to publication.

MEMBERSHIP APPLICATIONS APPROVED FOR PUBLICATION

The executive committee has approved for publication the names of the following candidates for membership in the Association. This does not constitute an election but places the names before the membership at large. If any member has information bearing on the qualifications of these nominees, he should send it promptly to the Executive Committee, Box 979, Tulsa, Oklahoma. (Names of sponsors are placed beneath the name of each nominee.)

FOR ACTIVE MEMBERSHIP

Preston E. Cloud, Jr., Washington, D. C.
J. David Love, L. W. Stephenson, Chester R. Longwell
James Michael Curran, Jr., Corpus Christi, Tex.
L. B. Herring, C. C. Miller, Robert Hendrickson
Frank Floyd Fulk, Tyler, Tex.
Selden R. Self, B. W. Allen, Delmar R. Guinn
Constant Godefroy, Toronto, Ont., Canada
Chester Naramore, O. C. Wheeler, Oliver B. Hopkins
Frank Cyril Kallina, Corpus Christi, Tex.
Cecil D. Robinson, Ira H. Stein, T. Preston Ware, Jr.
Noel Raymond Lamb, Hobbs, N. M.
Charles D. Vertrees, Charles P. Miller, Glenn Staley
Frederick Allan McKinnon, Calgary, Alta., Canada
T. A. Link, John A. Allan, W. C. Howells
James Dale Perryman, Dallas, Tex.
W. W. Newton, Myron C. Kiess, Lynn K. Lee
Woodson Miller Tottenham, Dallas, Tex.
Paul E. Nash, Henry C. Cortes, J. J. Simkins
Robert Jackson Wells, Bakersfield, Calif.
T. P. Ellsworth, Joseph LeConte, Mason L. Hill

FOR ASSOCIATE MEMBERSHIP

Jose Rafael Dominguez D., Maracaibo, Venezuela, S. A.
Herbert M. Dawson, A. J. Freie, Walter Hegwein
Wilson Vernon Glass, Tyler, Tex.
R. M. Trowbridge, C. I. Alexander, G. J. Loetterle
Frederick Henry Kate, Centralia, Ill.
L. M. Clark, Norman S. Hinchey, H. L. Koch
Edward Richard Ries, Freeman, S. D.
V. E. Monnett, F. A. Melton, C. G. Lalicker
John Blaine Williams, Houston, Tex.
Fred M. Bullard, L. C. Snider, Hal P. Bybee
George Miller Wilson, Urbana, Ill.
Harold R. Wanless, L. E. Workman, Alfred H. Bell
Perry Michael McNally, Brownfield, Tex.
V. G. Feather, A. J. Hintze, W. H. Courtier

FOR TRANSFER TO ACTIVE MEMBERSHIP

John Van Nostrand Dorr, II, Washington, D. C.
Arthur A. Baker, Hugh D. Miser, Thomas A. Hendricks
Ernest Willard Fosshage, Tulsa, Okla.
George P. Hardison, J. M. Wanenmacher, G. S. Lambert

CURRENT NEWS AND PERSONAL ITEMS OF THE PROFESSION

J. Elmer Thomas, recently resigned as special assistant to Deputy Petroleum Administrator Ralph Davies, has opened a temporary office in the Fort Worth National Bank Building, Fort Worth, Texas.

Hillard W. Carey, recently chief geologist for the Halliburton Oil Well Cementing Company, has been appointed head of the production engineering department of the Houston Natural Gas Corporation, Houston, Texas.

J. M. Nisbet, manager of the land, lease, and geological division of the Cities Service Oil Company, has been elected to the vice-presidency.

Ralph W. Imlay, of the United States Geological Survey, Washington, D. C., spoke before the Houston Geological Society, April 22, on "The Jurassic Formation of the Gulf Coast."

J. N. McGirl has been appointed district manager of the land and exploration department of the Tide Water Associated Oil Company at Tulsa.

Frederick M. Swain, of the Phillips Petroleum Company, spoke on "Stratigraphy of the Cotton Valley Beds," before the Shreveport Geological Society, May 5.

Malvin G. Hoffman is chief of the facilities section of the Production Division of the Petroleum Administration for War, Washington, D. C. Mr. and Mrs. Hoffman announce the birth of a son, Stanley Ray Hoffman, March 13.

Daniel A. Busch has resigned his teaching position at the University of Pittsburgh to accept a position as a petroleum geologist with the Topographic and Geologic Survey of Pennsylvania. His office address is 105 State Hall, University of Pittsburgh, Pittsburgh, Pennsylvania.

H. M. Kirk is resident geologist in Haiti for The Atlantic Refining Company. He was at the home office of the company in Philadelphia in the early part of April.

W. E. Wrather, a past-president of the Association, and for some time on the Board of Economic Warfare metals and minerals division, has been appointed director of the United States Geological Survey. He succeeds W. C. Mendenhall, who has retired after 48 years of service with the Survey.

Melville W. Fuller has been appointed chief geologist of the Carter Oil Company, Tulsa, Oklahoma, succeeding Harold F. Moses, who is manager of the exploration department. Lee C. Lamar succeeds Fuller as geologist for the company's eastern division at Mattoon, Illinois.

Paul Weaver, of the Gulf Oil Corporation, discussed "The Geophysicist as a Forecaster," before the Houston Geological Society, April 1.

John L. Rich, of the University of Cincinnati, has finished a long itinerary of local geological societies, presenting his illustrated lecture, "Problems of South American Geology as Suggested by an Aerial Traverse."

Paul D. Krynine, of Pennsylvania State College, has been discussing "Diastrophism and the Evolution of Sedimentary Rocks," before local geological societies.

S. H. Knight, of the University of Wyoming, presented a chalk talk on "The Genesis of the Late Paleozoic Sediments of Southwestern Wyoming," before the Rocky Mountain Association of Petroleum Geologists, at Denver, April 5.

W. L. Russell, of the Stanolind Oil and Gas Company, talked on "Radioactivity of Sedimentary Rocks," before the Tulsa Geological Society, April 19.

GEOLOGICAL AND GEOPHYSICAL SOCIETIES

COLORADO

ROCKY MOUNTAIN ASSOCIATION OF PETROLEUM GEOLOGISTS
DENVER, COLORADO

President - - - - - - - Ralph D. Copley
The California Company
1st Vice-President - - - - - C. E. Erdmann
U. S. Geological Survey
2nd Vice-President - - - - - John E. Blixt
The Texas Company
Secretary-Treasurer - - - - Robert E. Spratt
U. S. Geological Survey, 208 Custom House

Dinner meetings, first and third Mondays of each month, 6:15 P.M., Cosmopolitan Hotel.

ILLINOIS

ILLINOIS GEOLOGICAL SOCIETY

President - - - - - - - - Darsie A. Green
The Pure Oil Company, Box 311, Olney

Vice-President - - - - - - J. Rex McGehee
Shell Oil Co., Inc., Box 476, Centralia

Secretary-Treasurer - - - - - Fred H. Moore
Magnolia Petroleum Corp., Box 535, Mt. Vernon

Meetings will be announced.

INDIANA-KENTUCKY

INDIANA-KENTUCKY GEOLOGICAL SOCIETY
EVANSVILLE, INDIANA

President - - - - - - - Richard S. Hicklin
Carter Oil Company

Vice-President - - - - - - Charles J. Hoke
Phillips Petroleum Company

Secretary-Treasurer - - - - Robert F. Eberle
The Superior Oil Company

Meetings will be announced.

KANSAS

KANSAS GEOLOGICAL SOCIETY
WICHITA, KANSAS

President - - - - - - - - - E. P. Philbrick
Magnolia Petroleum Company
Vice-President - - - - - - Jack M. Copass
Amerada Petroleum Corp., Box 995
Secretary-Treasurer - - - Robert B. McNeely
209 Ellis-Singleton Building
Manager of Well Log Bureau - Harvel E. White

Regular Meetings: 7:30 P.M., Geological Room, University of Wichita, first Tuesday of each month. Visitors cordially welcomed.

The Society sponsors the Kansas Well Log Bureau which is located at 412 Union National Bank Building.

LOUISIANA

NEW ORLEANS GEOLOGICAL SOCIETY
NEW ORLEANS, LOUISIANA

President - - - - - - - - - - J. W. Hoover
The California Co., 1818 Canal Bldg.
Vice-President - - - - - - - - H. C. Petersen
Freeport Sulphur Co., American Bank Bldg.
Secretary-Treasurer - - - - W. J. Gillingham
Schlumberger Well Surveying Corporation
452 Canal Bldg.

Meets the first Monday of every month, 7:30 P.M., St. Charles Hotel. Special meetings by announcement.

LOUISIANA

THE SHREVEPORT GEOLOGICAL SOCIETY
SHREVEPORT, LOUISIANA

President - - - - - - - - - G. D. Thomas
Shell Oil Company, Inc.
Vice-President - - - - - - R. M. Wilson
Ohio Oil Company
Secretary-Treasurer - - - - - T. H. Philpott
Carter Oil Company, Drawer 1739

Meets the first Monday of every month, October to May, inclusive, 7:30 P.M., Civil Courts Room, Caddo Parish Court House. Special dinner meetings by announcement.

LOUISIANA

SOUTH LOUISIANA GEOLOGICAL SOCIETY
LAKE CHARLES, LOUISIANA

President - - - - - - - - - H. E. McGlasson
Stanolind Oil and Gas Company
Vice-President - - - - - - - - - C. B. Roach
Shell Oil Company, Inc.
Secretary - - - - - - - - - - A. L. Morrow
Magnolia Petroleum Company
Treasurer - - - - - - - - - D. N. Rockwood
Union Producing Company

Meetings: Luncheon 1st Wednesday at Noon (12:00) and business meeting third Tuesday of each month at 7:00 P.M. at the Majestic Hotel. Visiting geologists are welcome.

MICHIGAN

MICHIGAN GEOLOGICAL SOCIETY

President - - - - - - - George D. Lindberg
Sun Oil Company, Toledo, Ohio

Vice-President - - - - Edward J. Baltrusaitis
Gulf Refining Company, Box 811, Saginaw

Secretary-Treasurer - - - - Mrs. Lucille Esch
State Geological Survey, Lansing

Business Manager - - - - - William Schulz
Cities Service Oil Co., Mt. Pleasant

Meetings: Bi-monthly from November to April at Lansing. Afternoon session at 3:00, informal dinner at 6:30 followed by discussions. (Dual meetings for the duration.) Visiting geologists are welcome.

TEXAS

EAST TEXAS GEOLOGICAL SOCIETY
TYLER, TEXAS

President - - - - - - - - - - E. B. Wilson
Sun Oil Company

Vice-President - - - - - Laurence Brundall

Secretary-Treasurer - - - - - - - B. W. Allen
Gulf Oil Corporation

Meetings: Monthly and by call.
Luncheons: Every Monday at 12:00 noon, Blackstone Hotel.

HOUSTON GEOLOGICAL SOCIETY
HOUSTON, TEXAS

President - - - - - - - - Donald M. Davis
Pure Oil Company

Vice-President - - - - - Carl B. Richardson
Barnsdall Oil Company

Secretary - - - - - - - - - Hillard W. Carey
Houston Natural Gas Corp., Box 1188

Treasurer - - - - - - William F. Calohan
British-American Oil Producing Company

Regular meeting held the first and third Thursdays at noon (12 o'clock), Mezzanine floor, Texas State Hotel. For any particulars pertaining to the meetings write or call the secretary.

SOUTH TEXAS GEOLOGICAL SOCIETY
SAN ANTONIO, TEXAS

President - - - - - - - Wm. H. Spice, Jr.
Consulting, 2101 Alamo National Building

Vice-President - - - - - Harvey Whitaker
Consulting, 1409 Milam Building

Secretary-Treasurer - - - - Arthur H. Petsch
The Ohio Oil Co., 1417 Milam Building

Meetings: Third Tuesday of each month in San Antonio. Luncheon every Monday noon at Milam Cafeteria, San Antonio.

FORT WORTH GEOLOGICAL SOCIETY
FORT WORTH, TEXAS

President - - - - - - - - Karl A. Mygdal
The Pure Oil Company, Box 2107

Vice-President - - - - William J. Hilseweck
Gulf Oil Corporation

Secretary-Treasurer - - - Richard H. Schweers
The Texas Company, Box 1720

Meetings: Luncheon at noon, Worth Hotel, every Monday. Special meetings called by executive committee. Visiting geologists are welcome to all meetings.

NORTH TEXAS GEOLOGICAL SOCIETY
WICHITA FALLS, TEXAS

President - - - - - - - - - Earl M. Stilley
Consulting Geologist, 910 Staley Bldg.

Vice-President - - - - - Clinton Engstrand
Shell Oil Company, Inc.

Secretary-Treasurer - - - - Dan D. Heninger
The Ohio Oil Company, 615 Hamilton Bldg.

Luncheons and evening programs will be announced.

WEST TEXAS GEOLOGICAL SOCIETY
MIDLAND, TEXAS

President - - - - - - - - - Fred H. Wilcox
Magnolia Petroleum Company

Vice-President - - - - - Prentiss D. Moore
Moore Exploration Company

Secretary-Treasurer - - - - - Dana M. Secor
Atlantic Refining Company

Meetings will be announced

WEST VIRGINIA

THE APPALACHIAN GEOLOGICAL SOCIETY
CHARLESTON, WEST VIRGINIA
P. O. Box 2385

President - - - - - - - Charles Brewer, Jr.
Godfrey L. Cabot, Inc., Box 1473

Vice-President - - - - - - - H. J. Wagner
Public Service Commission

Secretary-Treasurer - - - - - Cramon Stanton
United Carbon Company, Box 1913

Editor - - - - - - - - - Robert C. Lafferty
In Service (Navy)

Meetings: Second Monday, each month, except June, July, and August, at 6:30 P.M., Kanawha Hotel.

THE SOCIETY OF EXPLORATION GEOPHYSICISTS

President - - - - - - - - - R. D. Wyckoff
Gulf Research and Development Company
Pittsburgh, Pennsylvania

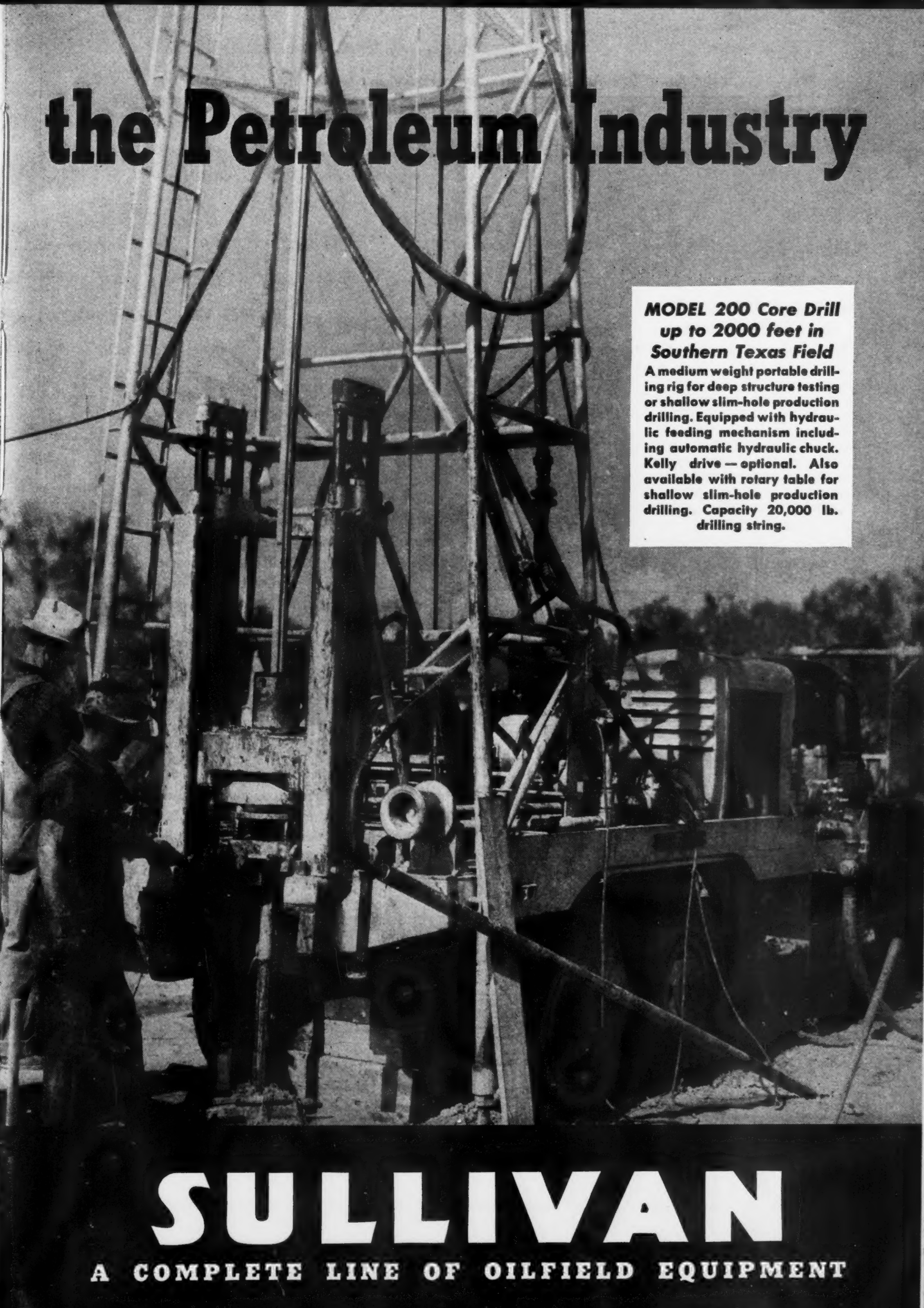
Vice-President - - - - William M. Rust, Jr.
Humble Oil & Refining Company, Houston, Texas

Editor - - - - - - - - - - - - J. A. Sharpe
Stanolind Oil and Gas Company, Tulsa, Oklahoma

Secretary-Treasurer - - - - - - - Hart Brown
Brown Geophysical Company, Box 6005
Houston, Texas

Past-President - - - - - - - Frank Goldstone
Shell Oil Company, Inc., Houston, Texas

Business Manager - - - - - - - - J. F. Gallie
P.O. Box 1925, Washington, D.C.



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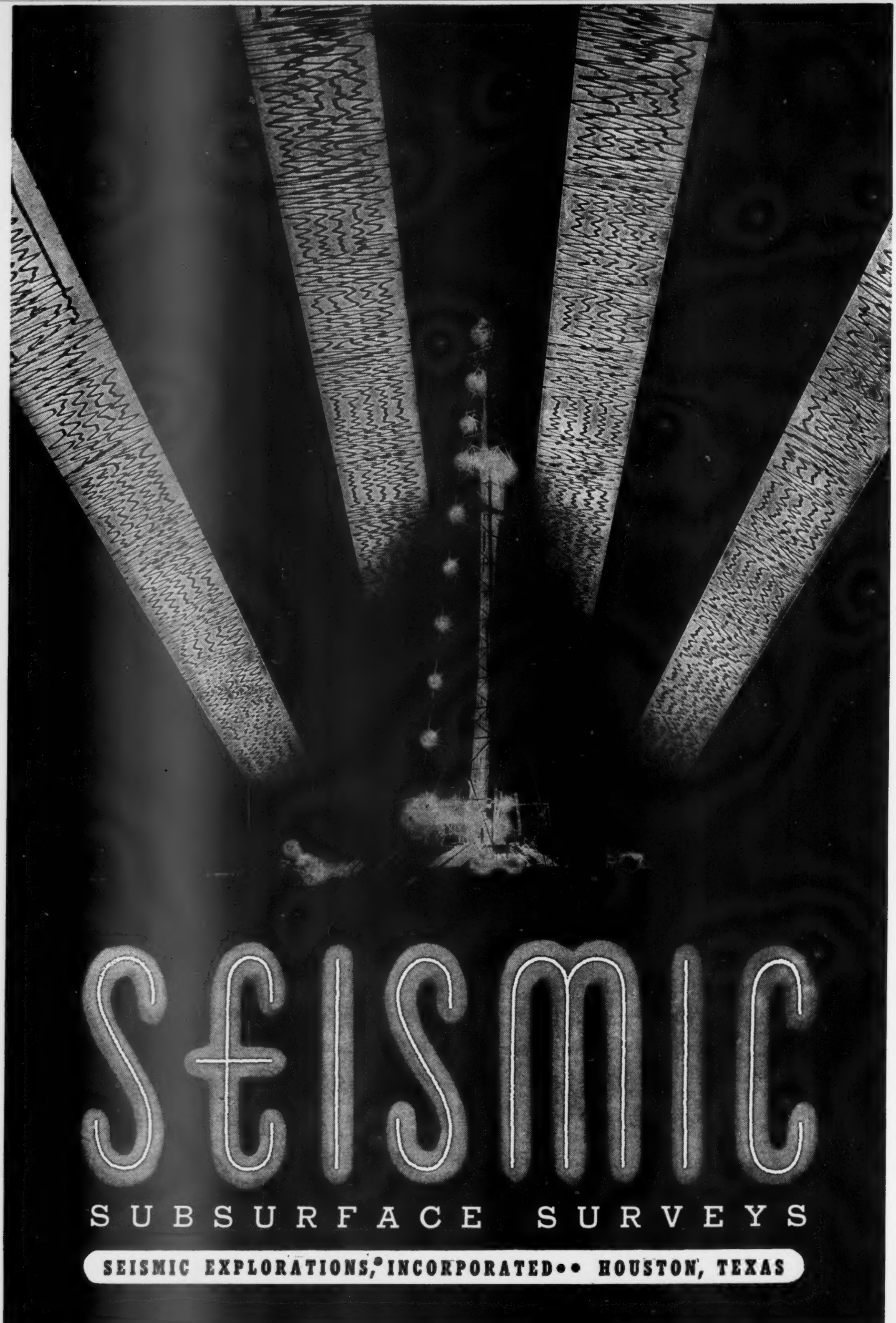
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